Wastes & Pollution Sources

of Abu Dhabi Emirate, United Arab Emirates

هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI

مبادرة ابوظبي العالمية للبيانات البيئية
Abu Dhabi Global
Environmental Data Initiative

Wastes & Pollution Sources

of Abu Dhabi Emirate, United Arab Emirates

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- البيانات
- الأدوات والأساليب
- التوعية
- بناء القدرات
- السياسة

الأوراق القطاعية

خلال السنوات الماضية قامت مختلف القطاعات المعنية بشؤون البيئة بتجميع كم من المعلومات المتنوعة بعدة صور تصف ما هو معروف عن البيئة في إمارة أبوظبي ودولة الإمارات العربية المتحدة والخليج العربي. خلال المرحلة الأولى لمبادرة أبوظبي العالمية للبيانات البيئية، تم تنظيم سلسلة من ورش العمل في عام ٢٠٠٥ لجمع المعنيين من هذه المنظمات ، لتحديد القطاعات ذات الصلة، ووضع إطار العمل لكل ورقة قطاعية، ومعالجة الاحتياجات الاجتماعية والاقتصادية والبيئية الرئيسية في إطار كل القضايا المتعلقة في القطاع . من خلال هذا الورش، تم إعداد ثماني ورقات لقطاعية ونشرها:

- التلوث وإدارة النفايات
- القوانين والسياسات البيئية
- الموارد المائية
- الجغرافيا الطبيعية لإمارة أبوظبي
- البيئة البحرية والساحلية
- التراث التاريخي والأثري والثقافي
- التطور الاقتصادي والسكاني
- التعليم والتوعية البيئية

وتم إعداد قطاع إضافي كجزء من البرنامج الأصلي، ومع ذلك، وسيتم نشرها للمرة الأولى كجزء من المرحلة الثانية:

- البيئات البرية وموارد الأرض

و لأن الأوراق القطاعية هي مجموعة من أفضل المعارف المتاحة المتعلقة بالقطاعات البيئية والاجتماعية-الاقتصادية الرئيسية وتمثل أساس كافة المخرجات التي سيتم إصدارها لاحقا كجزء من المرحلة الثانية للمبادرة، تم مراجعة الأوراق القطاعية الأصلية. وتم خلال ورشة العمل الدولية التي عقدت في عام ٢٠٠٧ تحديد ما يلي:

- بشكل عام، تم إعداد الأوراق القطاعية الأصلية بشكل جديد قدم فيها مجموعة قيمة من المعلومات
- لم تصل مشاركة الشركاء والجهات المعنيين إلى الحد المخطط له
- تم أعداد الأوراق القطاعية بدون دعم كافي من الهيئة أو الشركاء والجهات المعنيين، وبالتالي، كان على مؤلف الورقة القطاعية تحمل عبء إعداد ورقة هذا القطاع في وقت زمني محدود نوعا ما
- في بعض الحالات كانت البيانات المستخدمة قديمة نسبيا
- لم يتم إضفاء الطابع المؤسسي على عملية جمع البيانات وتبادلها

تهدف مراجعة المبادرة في إطار المرحلة الثانية إلى معالجة هذه الثغرات، فضلا عن غيرها من الثغرات التي تم تحديدها كجزء من الأوراق الأصلية. ولأن تنفيذ مهمة فرق العمل تم كجزء من المرحلة الثانية من البرنامج، فقد تم تقديم الدعم على جميع المستويات لمساعدة موظفي هيئة البيئة – أبوظبي والشركاء والجهات المعنية على معالجة وتحديد الثغرات، وجمع البيانات وإجراء التحليلات وتطوير مخرجات البيانات المكانية، وبناء العلاقات مع الشركاء والجهات المعنيين، وفي نهاية المطاف ، إعداد الورقة القطاعية وتنقيحها.

وتشكل الأوراق القطاعية مصدرا قيما للمعلومات البيئية والاجتماعية والاقتصادية لأبوظبي وتم استخدمها لمراجعة وتنقيح تقرير حالة البيئة لإمارة أبوظبي فضلا عن إعداد الأطلس البيئي لأبوظبي (النسختين المطبوعة والتفاعلية).

ولمزيد من المعلومات حول المبادرة أو للوصول لنسخة الكترونية من الأوراق القطاعية، يرجى زيارة الموقع الإلكتروني في www.agedi.ae.

ما هي مبادرة أبوظبي العالمية للبيانات البيئية ؟

تم إطلاق مبادرة أبوظبي العالمية للبيانات البيئية في الثاني من سبتمبر ٢٠٠٢ خلال مؤتمر القمة العالمي للتنمية المستدامة الذي عقد في مدينة جوهانسبرغ بجنوب إفريقيا من قِبل دولة الإمارات العربية المتحدة، كمبادرة شراكة من الصنف الثاني، لتكون أداة مبتكرة لِتنفيذ الأحكام المتعلقة بالبيئة والواردة في الفصل ٤٠ من جدول أعمال القرن ٢١ وفي الأهداف الإنمائية للألفية.

وفي أوائل عام ٢٠٠٧ ، نظمت بأبوظبي ورشة عمل دولية لاستعراض الانجازات التي حققها برنامج المبادرة ووضع خطة إستراتيجية لمدة خمس سنوات. وعلى هذا النحو، بدأت المرحلة الثانية من المبادرة في عام ٢٠٠٨ بناءا على ما تم انجازه في المرحلة الأولى، في حين تم معالجة الفجوات التي تم تحديها من خلال المعلومات التي وفرتها الجهات المعنية خلال ورشة العمل.

ولا تزال الرؤيا التي تعمل وفقها المبادرة في المرحلة الثانية هي "وضع وتنفيذ نماذج عملية يمكن تكرارها وتكييفها من أجل إنشاء هيكل أساسي للبيانات البيئية المكانية عالية الجودة، للمساهمة في توفير القاعدة العلمية لاتخاذ القرارات". وسيتم في المرحلة الثانية استخدم الدروس المستفادة لتحقيق نجاح أفضل في تنفيذ المبادرة في مرحلته الثانية.

وسيركز البرنامج الحالي على وضع سلسلة من المخرجات التي تتناول قضايا محددة في حين يتم تحقيق نتائج مؤسسية معينة، بما في ذلك:

١. توفير بيانات بيئية أكثر جودة
٢. تحديد الثغرات في البيانات والأولويات
٣. تنسيق أقوي وشراكات لتبادل البيانات
٤. أساليب وأدوات أفضل للمعلومات
٥. ربط الإستراتيجية والتشغيل بشكل أفضل
٦. تحسين البنية التحتية البشرية والتقنية
٧. مؤسسة أقوي بشكل عام

والمخرجات التي تم تحديدها في إطار عملية التنمية هي أمور مترابطة ومتعاقبة مع المخرجات الأولية لدعم المعلومات والتفاهمات التي تصب في الأنشطة اللاحقة. وهي تشمل ما يلي :

- مراجعة الأوراق القطاعية وقاعدة المعرفة
- مراجعة وتنقيح تقرير حالة البيئة
- الأطلس البيئي التفاعلي
- تعزيز بوابة البيانات المكانية
- تحسين الموقع الالكتروني
- مؤشر الأداء الحكومي لابوظبي
- برامج وضع الإستراتيجية

ولضمان تحقيق نتائج ايجابية وتوفير الموارد التقنية الكافية للقيام بتطوير المخرجات، تم إنشاء مجموعة من فرق العمل بهدف تجميع الموارد لدعم فرق كل مخرج من المخرجات المبادرة. وتشمل هذه ما يلي :

What is AGEDI ?

The Abu Dhabi Global Environmental Data Initiative (AGEDI) program was fashioned around the United Nations World Summit for Sustainable Development (WSSD) Type II Partnership in 2002 as a tool to support the environmental provisions of Chapter 40 of Agenda 21 and the Millennium Development Goals.

In early 2007, an international workshop was conducted in Abu Dhabi to review the accomplishments of the AGEDI program and develop the next five year strategic plan. As such, AGEDI Phase II began in 2008 building off the accomplishments of the initial phase, while addressing gaps identified through stakeholder input during the workshop.

The vision of AGEDI Phase II remains to be a "replaceable, networked, adaptive and working model for the development and use of high quality spatial environmental data by all users within the Emirate of Abu Dhabi that will support sustainable decision and policy making." Phase II will use lessons learned to better guide the successful implementation of AGEDI in its second phase.

The focus of the current program is to develop a series of interrelated products that address specific issues while achieving certain institutional outcomes, including:

1. Better current and quality environmental data
2. Identification of data gaps and priorities
3. Stronger coordination and data sharing partnerships
4. Better information methods and tools
5. Better links between strategy and operation
6. Improved human and technical infrastructure
7. Stronger organization overall

The specific products under development are interdependent and sequential, with early products yielding information and understandings that feed into subsequent activities. These include the following:

- Sector Paper Review and Knowledgebase
- SoE Review and Refinement
- Environmental Atlas
- Interactive Environmental Atlas
- Geospatial Portal Enhancement
- Website Refinement
- EPI for Abu Dhabi
- Programs Alignment Strategy

To ensure positive outcomes and adequate technical resources for carrying out the product development, a series of task forces were established as pooled resources to support each product team. These include:

- Data
- Tools and Methods
- Outreach
- Capacity Building
- Policy

Sector Papers

Over the years, different organizations compiled a variety of information in many forms that describe what is known about Abu Dhabi, the UAE and the Arabian Gulf Region. Through the initial AGEDI phase, a series of workshops were developed in 2005 to bring together stakeholders from all these organizations, identify the sectors that were relevant, design a framework for each Sector Paper, and address the key environmental and socioeconomic issues relevant under each sector. Through this effort, eight Sector Papers were completed and published:

- Waste Management and Pollution
- Environmental Policy and Regulation
- Water Resources
- Physical Geography
- Marine and Coastal Environment
- Paleontological and Archaeological Resources
- Population, Development and Economy
- Environmental Education and Awareness

One additional sector was scoped as part of the original program, however, will be published for its first time as part of AGEDI Phase II:

- Terrestrial Environment

Because the Sector Papers are a collection of the best available knowledge pertaining to key environmental and socioeconomic sectors and serve as the basis for all subsequent products to be developed as part of AGEDI Phase II, a review of the original Sector Papers was conducted. Already known through the international workshop held in 2007 was:

- Overall, the original papers were done well and provided a wealth of information
- Stakeholder participation did not reach the level originally intended
- Sector Papers were developed without much agency or stakeholder support, and therefore, became the burden of the Sector Paper authors under a fairly limited timeframe
- Data used was outdated in some cases
- Data collection and sharing did not get institutionalized

The review under AGEDI Phase II sought to address these gaps, as well as the other gaps already identified as part of the original papers. Because the Task Forces were implemented as part of the Phase II program, support was provided at all levels to assist EAD staff and stakeholders in addressing and identifying gaps, collecting data, conducting analyses and developing spatial products, building stakeholder relationships, and ultimately, developing a refined Sector Paper.

The Sector Papers are a source of valuable environmental and socioeconomic information for Abu Dhabi and were used to review and refine the State of the Environment (SoE) report for Abu Dhabi as well as develop the Abu Dhabi Environmental Atlas (both hard-copy and interactive versions).

For more information and online versions

For more information about AGEDI or to access online versions of the Sector Papers, please visit the AGEDI website at www.agedi.ae

وقد تم جمع القدر الأكبر من المعلومات لإعداد هذه الورقة لتغطية مجالات محددة وفقاً لتنسيق ونظام متفق عليه بصورة مسبقة. وتم لاحقاً إدخال بعض التعديلات في الموضوعات وطريقة التناول بناء على نوعية وكمية المعلومات التي يمكن جمعها في النهاية.

وقد كانت كمية المعلومات والبيانات التحليلية التي تم جمعها في المرة الأولى كافية بقدر معقول في بعض المجالات مثل النفايات البلدية والنفايات الطبية والنفايات السائلة والنفايات الصلبة الخطرة الناتجة من الصناعات النفطية ونوعية الهواء المحيط. كما كانت غير كافية في مجالات أخرى مثل النفايات الخطرة من الصناعات غير النفطية ونوعية البيئة البحرية. ويتوقع أن يتم حل المشكلات المتصلة بعدم كفاية البيانات بصورة تدريجية حين يتم إشراك جميع الجهات صاحبة العلاقة في إعداد الأوراق القطاعية في السنوات التالية، وأيضاً من خلال توفير آليات أفضل لجمع البيانات.

كجزء من مراجعة الورقة القطاعية الحالية وتدقيقها في المرحلة الثانية لبرنامج مبادرة أبوظبي العالمية للبيانات البيئية في هيئة البيئة – أبوظبي، لوحظ عدم وجود تغيرات مؤثرة في البيانات والمعلومات الواردة في الإصدار الأول من التقرير. ونظراً لبعض المبادرات الرئيسية التي تم تنفيذها منذ عام 2005م والتي يلزم إدماجها في الورقة لاستكمال الصورة الكاملة للوضع الحالي لإدارة النفايات في الإمارة، فقد قرر فريق مبادرة أبوظبي العالمية للبيانات البيئية إضافة قسم في المقدمة للحديث عن هذه المبادرات، بدلاً عن تحديث الأقسام الحالية للورقة والتي ما تزال تحتوي على معلومات ذات قيمة كبيرة ويمكن استخدامها للأغراض المرجعية.

البيئات البرية وموارد الأرض

كانت هذه الورقة من بين العديد من الأوراق التي بدأ إعدادها في عام 2005م في إطار الإجراءات اللازمة لإعداد أول تقرير عن حالة البيئة في إمارة أبوظبي. وتم تحديد موضوعات الورقة ومحتوياتها في ورشة عمل عقدت في 30 مايو 2005م، شاركت فيها العديد من الجهات المعنية. وقد استمر التنسيق مع تلك الجهات بعد الورشة لتوفير البيانات والمعلومات والمشاركة في كتابة الورقة.

ونظراً لأن شركة أبوظبي الوطنية للبترول (أدنوك) كانت الجهة الوحيدة التي ساهمت بتوفير البيانات والاحصائيات، فقد تم إعداد هذه الورقة بواسطة المتخصصين في هيئة البيئة – أبوظبي بناء في معلومات من مصادر ثانوية - في الغالب - وبصفة خاصة من مطبوعات دائرة حماية البيئة بالهيئة (قطاع الإدارة البيئية) والتقارير الاستشارية المتوفرة ومطبوعات وتقارير الجهات الأخرى. كما طلب من الجهات صاحبة العلاقة مراجعة المسودة وتم مراعاة الملاحظات الورادة من ممثلي شركة أبوظبي الوطنية للبترول وهيئة مياه وكهرباء أبوظبي في إعداد المسودة النهائية.

يستعرض الفصل الثاني من هذه الورقة الوضع التنظيمي في إمارة أبوظبي فيما يتعلق بإدارة النفايات ومصادر التلوث. أما الفصل الثالث فيتناول القنوات الرئيسية للنفايات ومصادر التلوث وتحديداً النفايات الصلبة (العادية والخطيرة) والسائلة والغازية. ويحدد هذا الفصل الأنواع المختلفة من النفايات ومصادر التلوث مع توفير معلومات تاريخية عن إدارتها وتحديد مصادرها وتقديم تقديرات كمية – حيثما أمكن – ومناقشة الممارسات الإدارية الحالية والقضايا والمشكلات الرئيسية المتصلة بها والظواهر والاتجاهات العامة والخطوات المستقبلية. ويتضمن الفصل الرابع ملخصاً للمجالات التي لا تتوفر عنها معلومات كافية ويناقش طرق العمل المستقبلية.

ونظراً لأن الاعتبارات المتعلقة بإدارة النفايات ومكافحة التلوث تشهد تطورات سريعة، فإن متن هذه الورقة يعكس الوضع في إمارة أبوظبي حتى ديسمبر 2005م، فيما تم تناول التطورات التي أتت بعد ذلك التاريخ في صدر الورقة.

WASTE AND POLLUTION SECTOR PAPER

EXECUTIVE SUMMARY

In 2005, this paper was one of several being prepared as part of a process that will lead to the preparation of the first "State of the Environment Report" (SoE) for the Emirate. The scope and outline of the paper were decided in a framing workshop held on May 30, 2005, in which other concerned agencies were represented. Main concerned agencies were contacted after the workshop to provide required data and information and to participate in paper writing. ADNUC was the only agency to contribute, by providing data and statistics. So, the paper was prepared by staff from EAD, mostly based on secondary information sources, notably EPD publications, available consultant reports, and publications of other agencies. Concerned agencies were also requested to review the draft paper, and comments from representatives of ADNUC and ADWEA were considered in finalizing it.

Chapter 2 of this paper provides an overview of the regulatory situation in Abu Dhabi Emirate with regards to waste management and pollution sources. Chapter 3 addresses major waste streams and pollution source, namely, solid wastes (both hazardous and non-hazardous), liquid discharges, and air emissions. For each waste type or pollution source, the paper defines the waste or the source, gives a brief history of its management, identifies its sources, provides quantitative estimates where possible, explains its present management practices, and discusses its major issues, trends and future actions. Chapter 4 provides a summary of information gaps and discusses the way forward. Because waste management and pollution control aspects in Abu Dhabi Emirate are evolving rapidly, the body of this paper should be considered as reflecting the status in Abu Dhabi Emirate as of December 2005. More recent developments are summarized in the preface of the paper.

In writing the paper, efforts were made to collect as much information as required to cover its pre-agreed scope, and to present the information in the pre-agreed format. However, changes had to be introduced in the scope as well as in the presentation, based on the quantity and quality of the information that could ultimately be collected. Collected information and first-hand quantitative data were reasonably adequate for some aspects (e.g., domestic wastes; medical wastes; liquid and solid hazardous wastes from the oil industry; and ambient air quality) but quite deficient for others (e.g., hazardous wastes from non-oil industries; and marine environment quality). It is anticipated that problems related to data inadequacy will gradually be resolved in subsequent years as all stakeholder agencies get involved in preparing the sector papers and the SUER, and through provision of better mechanisms for data collection.

As part of the current sector paper review and refinement process as part of the AGEDI Phase II program at EAD, it was determined that the updates in the waste management sector were minimal in regards to data development and sharing opportunities, and as such, there was minimal information and/or data useful for more comprehensively updating the sector paper. However, there were some key initiatives that took place since 2006 that needed to be called out so that the current waste management situation in Abu Dhabi could be better understood. The AGEDI Team, therefore, decided to include an introductory section that outlined these changes rather than updating the entire paper, which still has much useful information that can be accessed for reference.

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UPDATES TO WASTE AND POLLUTION SECTOR PAPER

1. Introduction

Through the sector paper review and refinement process, stakeholders from Environment Policy Sector (EPS) of Environment Agency – Abu Dhabi (EAD), including the original authors of the Waste and Pollution Sector Paper, and the newly formed Abu Dhabi Waste Management Center (ADWMC), were consulted to better understand the change that has occurred in the waste and pollution situation since the original publication of this paper. These discussions revealed that in terms of progress and documented changes in regards to data development, data sources and data sharing, as well as newly developed applications, initiatives or partnerships, the overall change has been minimal to the point that a complete "update" to the paper might not be warranted. However, some important events have taken place since the last publication including:

- Development of the Abu Dhabi Waste Management Center (ADWMC)
- Development of Abu Dhabi Waste Management Strategy
- Aerial surveys providing the locations of solid waste debris scattered throughout the wild areas of Abu Dhabi Emirate
- Air and Noise Quality Management.

Rather than redrafting the previous version of this sector paper, which is a rich source of information about the past and relatively current waste and pollution situation, the new developments since the last publication listed above will be documented in this preface.

2. Abu Dhabi Waste Management Center (ADWMC) and Strategy

In 2007, the Higher Committee for Waste Management was formed and chaired by the Secretary General of EAD. Other members of the Committee include:

- Health Authority Abu Dhabi (HAAD)
- Abu Dhabi Police
- Abu Dhabi Water and Electric Authority (ADWEA)
- Abu Dhabi National Oil Company (ADNOC)
- Executive Affairs Authority (EAA)
- Department of Municipal Affairs (DMA)
- Army
- Higher Corporation for Specialized Economic Zone.

The Committee established the Abu Dhabi Waste Management Center as an autonomous entity tasked with coordinating the delivery of the Waste Management Strategy throughout Emirate of Abu Dhabi through a full cycle, integrated, waste management system.

Population growth and increased development in the Emirate of Abu Dhabi are only some of the factor contributing to an increase in the development of waste, and at present the waste situation includes:

- Uncontrolled dumping
- Significant litter
- Limited recycling
- No uniform waste management practices
- High environmental impact

In an effort to address some of these problems and get a better handle on waste management within the Emirate, ADWMC was formed with some of the following responsibilities:

- To integrate waste management into a full cycle system
- To coordinate all waste management
- To develop a long term Waste Strategy
- To let and administer contracts

The Waste Management Strategy was completed in September 2008 and covers all aspects of waste management – beginning with the point of generation through to the ultimate treatment and disposal of wastes. The Waste Management Strategy will identify key areas, policies and regulations for targeted interventions to reduce and minimize waste generation in the first instance then to guide the recycling and disposal of the residuals in a manner that produces the greatest net social and economic benefits and the least environmental impacts.

The goal of the Waste Management Strategy is a "Cleaner Abu Dhabi". More specifically:

"Abu Dhabi will minimize the ecofootprint of the waste it produces and maximize the economic opportunities for recovering the embedded resources in a fully cycle system, by respecting the waste hierarchy, ensuring the polluter or user pays and utilizing the best global technologies."

3. Current ADWMC Projects

As part its mandate the ADWMC has begun the tendering of several projects to fill in gaps in current waste management service provision and to provide the foundation for the newly developed Strategy. The ADWMC seeks to fulfill a number of prime objectives in pursing the development and implementation of the individual projects, including:

- Avoid and minimise environmental and health pollution risks associated with storage, collection, transport, handling, re-use, recycling and disposal;
- Eliminate illegal dumping throughout the Emirate of Abu Dhabi;
- Provide alternative systems for processing, re-use and recycling in order to promote resource conversation and enhance carbon footprint initiatives;
- Employ the Best Practicable Environmental Options (BPEO) for management, processing, recycling and disposal in conjunction with the Best Available Control Technology (BACT);
- Implement appropriate systems to ensure that waste management is always controlled and environmentally safe, flexible and economically viable under local conditions within the Emirate of Abu Dhabi;
- Ensure that all facilities developed are designed, constructed, operated and maintained to stipulated minimum functional specifications, consistent with the best adopted international practices and standards;
- Achieve financing, execution and management of the projects, and associated service provision, in accordance with best international commercial practices to ensure the optimum benefits are obtained;
- Enhance environmental knowledge and awareness related among the individuals and the generators; and
- Undertake the projects in a manner that is financially viable and sustainable throughout the contract period.

Each project, where appropriate, is intended to provide a complete and integrated system for the “cradle to grave” collection, reception, recycling, treatment and/or disposal of all waste generated in the Emirate that requires secure and safe management and final disposal.

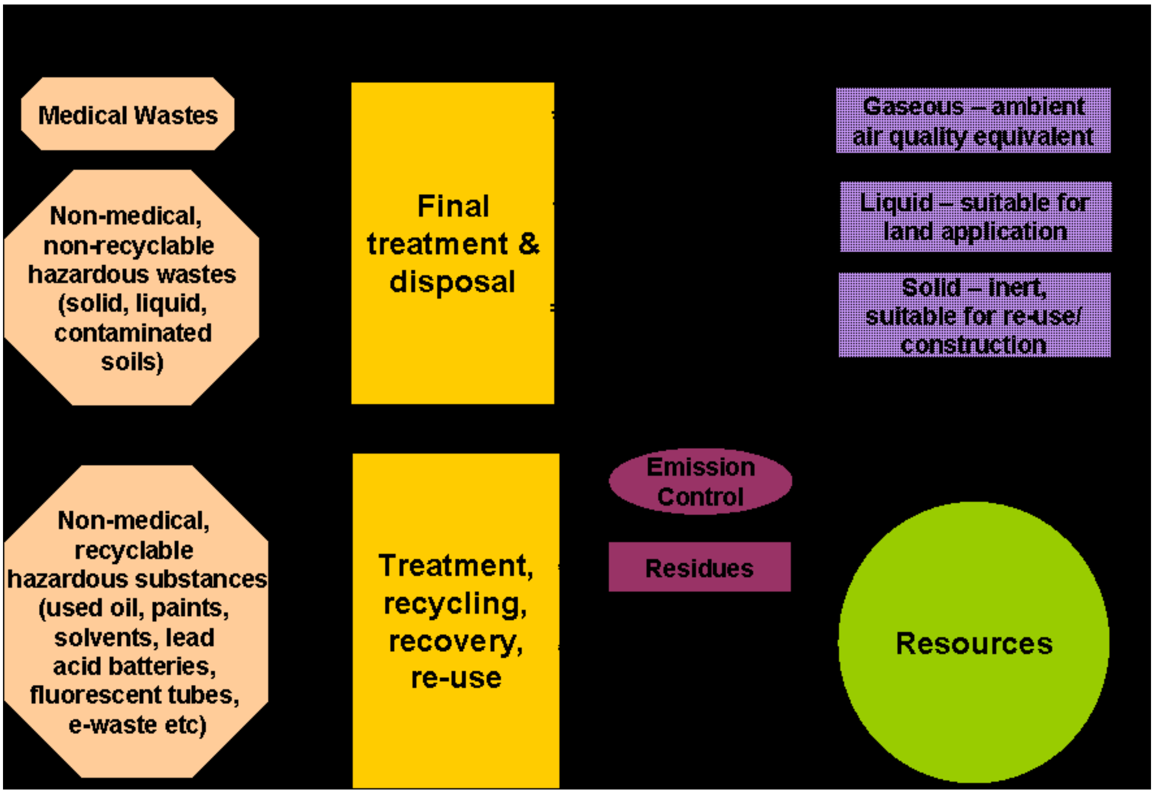
The diagram below indicates the projects that will be integrated as part of the Abu Dhabi Waste Management Strategy with brief descriptions to follow.

Other projects will be initiated in due course.

Hazardous Waste Management Project

Currently, management of Hazardous Wastes in the Emirate of Abu Dhabi may be characterised as follows:

- The management of Hazardous Waste in Abu Dhabi is at an early stage of development. There are very few approved facilities and the quantities of waste generated are estimates only.
- The processing and management of Hazardous Wastes is presently carried out by Environmental Service Providers (ESPs) who are approved and licensed by EAD.
- The ESPs are licensed for one or more of collection, transportation, storage, treatment and disposal.
- Radioactive wastes are controlled under separate legislation from other Hazardous Wastes.
- The oil industry and related organisations (through Abu Dhabi National Oil Company (ADNOC)) currently manage their own Hazardous Wastes. A Treatment and Disposal Facility is being constructed at Ruwais in the Western Region. Wastes are being stored pending the commissioning of this facility.
- An engineered cell for the disposal of hazardous wastes has been constructed at the new municipal solid waste landfill site at Al Ain.
- Medical wastes are being managed by two (2) current ESPs under short term collection, treatment and disposal contracts which are intended to provide an interim solution pending the implementation of the Hazardous Waste Project.
- Limited quantities of waste are processed elsewhere outside the Emirate.
- Incomplete information is currently available both with respect to the quantities of hazardous waste generated and how such wastes are managed, although the majority are believed to be disposed to landfill in the absence of any other alternative.
- Wastes other than the above may be disposed of (after approval) to the existing landfill at Al Dhafra. Illegal dumping has occurred.
- Hazardous Waste facilities require Permitting by EAD, which includes Environmental Impact Assessment and Risk Assessment.



The Project, as currently envisaged, includes the treatment of wastes from all municipalities in the Emirate (Abu Dhabi Municipality, Al Ain Municipality and Western Region Municipality), and Medical Wastes.

The overall concept of the Project is illustrated below:

The concept illustrates, and is premised on; the following key principles and targets:

- Maximum recovery of potentially recyclable materials and/or the recovery of resources;
- Final treatment and disposal only of those materials that cannot be recycled and/or re-used without some form of pre-treatment and treatment;
- Complete avoidance of emissions to air unless such emissions are equivalent to the quality and composition of ambient air;
- Complete avoidance of liquid discharges, treated or untreated, unless such discharges are suitable for application to land; and
- Complete avoidance of the disposal of residues to land, with such residues as may be generated as a consequence of any processing or treatment rendered inert and suitable for re-use.

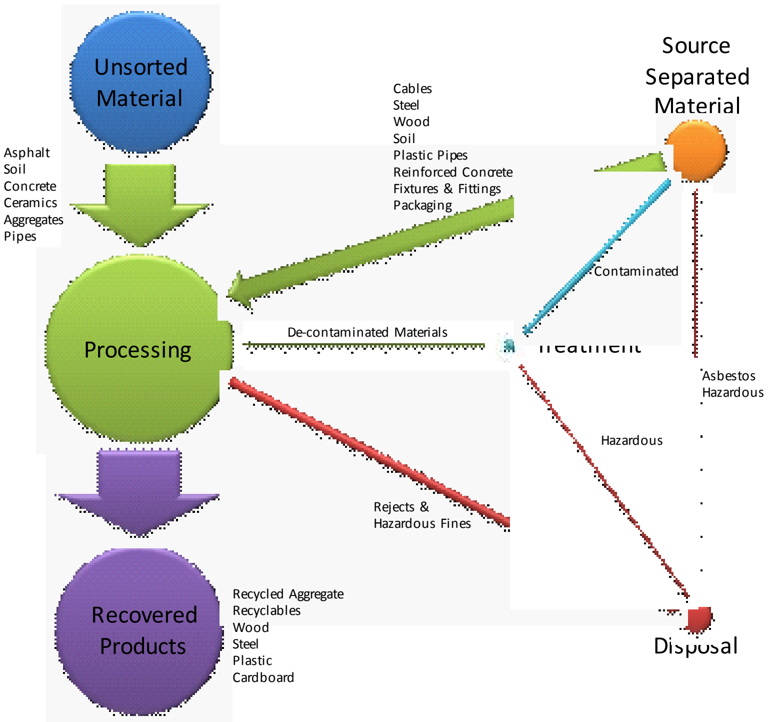
Construction and Demolition (C&D) Debris Management Project

Currently, no environmentally secure practices for the management, processing or disposal of C&D Debris exists in the Emirate of Abu Dhabi. The common practices for the management of these types of debris involve either:

- Dumping of C&D Debris adjacent to the construction area or its re-use as (structural) fill without any additional processing; or
- Dumping of C&D Debris at a large number of locations throughout the Emirate, at both legal dump sites and landfills and at illegal dumps. It is conservatively estimated that more than 12-15 thousand tonnes of C&D Debris are transferred to Al Dhafra landfill daily at present.

The services required for the Project include, but are not limited to the following tasks:

- Control and organization of the collection and transportation of C&D Debris within the Concession Area;
- Receiving and processing of all C&D Debris arriving at Project Facilities;
- Recovery of all potentially recyclable materials from the C&D Debris;
- Disposal of any residual C&D Debris that cannot be recycled or used beneficially; and
- Marketing and sale of resultant products.



The overall concept for this project is illustrated below:

Waste Tyres Management Project

There are currently no environmentally secure practices for the management and disposal of Waste Tyres in the Emirate of Abu Dhabi. The common practices for the management of Waste Tyres involve either:

- The export of tyres to other markets for subsequent re-use; or
- Dumping of tyres at a large number of locations throughout the Emirate, at both legal dump sites and landfills and at illegal dumps. The largest stockpile of tyres in the Emirate is located at Al Dhafra landfill, where it is conservatively estimated that more than ten million tyres have been stockpiled.

The services required for this project include, but are not limited to, the following primary tasks:

- Clearing all stockpiles at the existing dumping sites;
- Collection of Waste Tyres from different sources;
- Transportation and interim storage of Waste Tyres; and
- Processing, including re-using and recycling and marketing of resultant products.

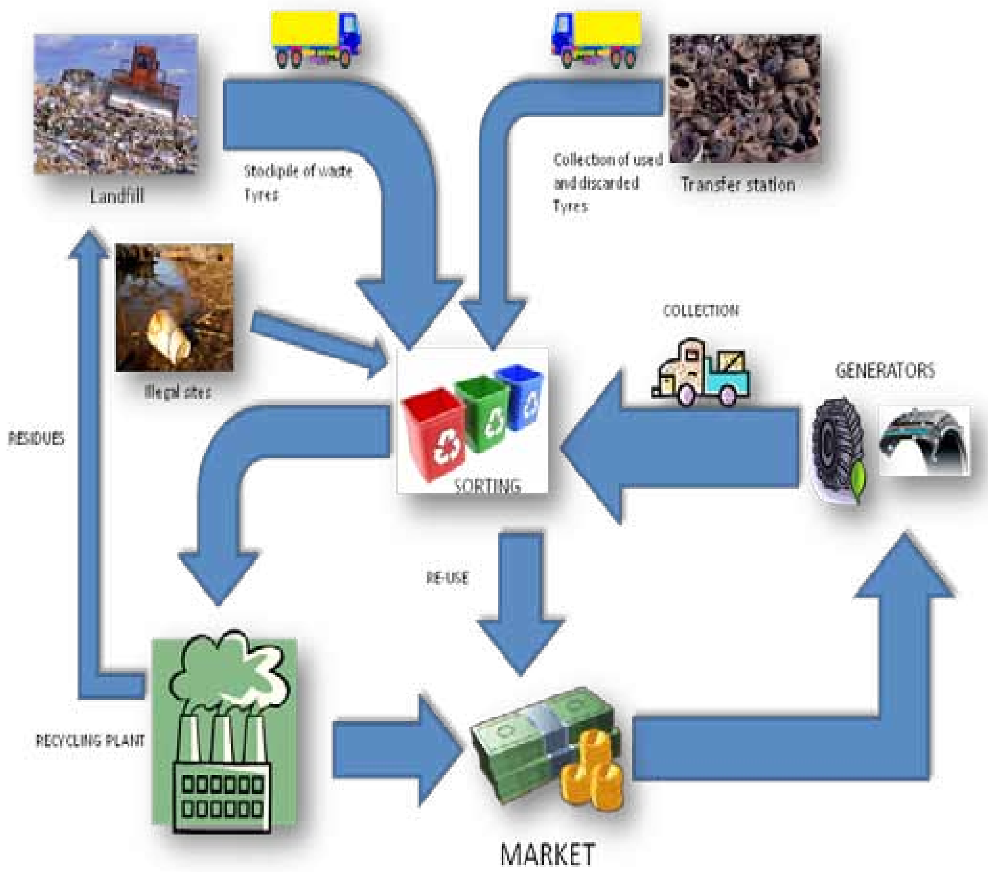
The overall concept for the Project is illustrated below:

Marine Waste Management Project

Existing management of Marine Wastes include:

- Waste Management in the UAE is the responsibility of each Emirate.
- The management of Marine Waste in Abu Dhabi is undertaken currently either as part of the municipal solid waste collection system or by a variety of private contractors upon request of individual port authorities.
- There are no data on the quantities of Marine Waste generated because such wastes are often not differentiated from municipal solid waste.
- Incomplete information is currently available both with respect to the quantities of Marine Waste generated and how such wastes are managed, although the majority are believed to be disposed to landfill in the absence of any other alternative.

Components of this strategy will ensure that there are regulations and financial incentives to discourage the dumping of any wastes to sea, even beyond the 12 nautical mile limit. The strategy, once developed, will apply to all



existing, as well as any new, port facilities regardless of whether these are government owned or privately owned. It is envisaged that the Project will include the following:

- The collection of all liquid and solid wastes (including quarantine and hazardous wastes);
- Techniques for the collection, storage and/or consolidation of any waste type, including segregation of recyclable components where feasible and economic;
- Transportation of all solid non-Hazardous Waste to a licensed transfer station, sorting plant or disposal facility;
- The temporary storage of Hazardous Waste on-site, in appropriate containment systems, pending collection by the Hazardous Waste Concessionaire;
- The collection and transportation of sewage from boats and facilities in the ports for final treatment and disposal at an approved the treatment plant;
- The scheduling of collection systems for all waste streams;
- Minimization and mitigation of adverse environmental impacts, to include the development and implementation of resource recovery and diversion of materials from disposal to landfill;
- Liaison with port facility operators in regards to waste management infrastructure planning, design, construction and servicing; and
- Integration with any current or proposed waste management systems for the Emirate of Abu Dhabi, to include the system currently under development for the management of Hazardous Wastes.

The overall concept of the Project is illustrated below:

Dump Sites Rehabilitation Project

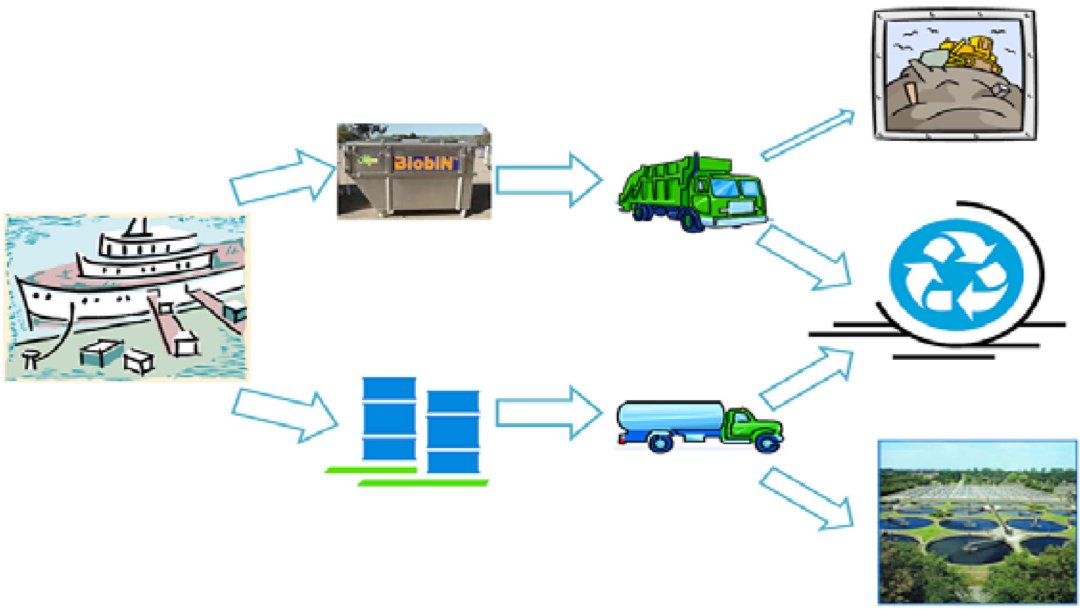
It is planned to introduce new controlled management processes at existing dump sites and landfills throughout the Emirate of Abu Dhabi. In addition, there will be a process of rehabilitating all existing dump sites in the Emirate in order to restore these sites to conditions close to those before tipping operations began. As part of this Project, ADWMC has developed a list of potential dumpsites for which rehabilitation may be required.

A partnership form of contract is planned for both upgrading operational standards and for rehabilitating existing dump sites, as the full scope of work cannot be fully and clearly defined at the outset. The need for a fresh and targeted management presence, particularly at the Al Dhafra site, is seen as critical to the early Best Practice upgrade of operations within the sector.

Some geological surveys have previously been undertaken but more relevant investigation and analysis is in process. This will include surveys, photographic records, soil/water data and waste analysis under a separate contract issued by the Abu Dhabi Waste Management Centre.

Al Dhafra Dump Site

The Al Dhafra Dump Site is the final disposal facility for the City of Abu Dhabi and the surrounding urban areas. It is situated approximately 78 km southwest of Abu Dhabi in a low-lying saline flat adjacent to the highway Route 65, approximately 30 km from the Western Region Highway Route 11.



The site is bounded on the east by the Al Dhafra highway and on the north, west, and south by sand dunes. The facility is located in an uninhabited part of the desert, and without vegetation of any kind. Vehicle access to the site is via a main access road from the Al Dhafra highway.

Al Dhafra landfill facility does not meet current international best practice, either in terms of management or engineering concept. There is no record of tonnages as the weighbridge facility has not been made operational until recently. There is no engineered lining system. Liquid wastes are co-disposed with solid materials and this has impacted groundwater, which lies close to the original ground level.

Much void space is currently taken by incoming Construction and Demolition (C&D) wastes, some of which may be contaminated.

Waste tyres have been surface dumped at the facility. These large zones are clearly shown as black on satellite imagery. Blue Bag medical waste is disposed of at the site following some rudimentary treatment prior to delivery.

Rehabilitation

To enable rehabilitation of all current and former dump sites in the Emirate, a new integrated waste management regime is planned to come on stream in Abu Dhabi from 2009, as noted above. With these projects it is hoped that the daily waste tonnage to be dealt with at the existing dump sites will be reduced significantly, thus permitting the adoption of improved management techniques and facilitating the commencement of rehabilitation activities.

Anticipated Work Activities

It is expected that some or all of the following work activities will be required for the rehabilitation of the dump sites:

- Site Surveys – control stations, topographic, aerial *etc*.;
- Site Investigations – geophysical, pits, boreholes, pump trials, reporting *etc*.;
- Materials Testing Services – Laboratory support on soils, waters, air – laboratory/field testing and monitoring;
- Improved Landfill Management – Technically competent management and operations team, as necessary – labour, materials and plant resourced;
- Technical Support Team –feasibility, design, approvals, procurement, supervisions and aftercare phases;
- Brown Field Remediation – health and safety, environmental management plans, construction waste management plans, site monitoring, method statements, materials classification, earthworks, materials screening, segregation and grading, soils clean-up techniques, waters clean-up techniques, risk assessment based (qualitative, quantitative);
- Landfill Cell Construction – Earthworks, lining, capping and pipe-work systems, monitoring, and restoration soils:
- Risk Appraisal – qualitative, quantitative, probabilistic – software options;
- Regulatory Compliance – planning, building, operating including discharge consents;
- Solar Pond Construction – earthworks, lining, pipe-work systems;
- Materials Processing and Recovery – shredding, screening, segregating, grading;
- Major Earthworks – Cut and Fill/Compaction, Stockpile/balancing Zone control;
- Environmental Monitoring – ground, waters, air;
- Environmental Management – Control of Site Activities – avoiding environmental impact;
- Human Health Protection – control of substances, ambient condition monitoring – gases, particulates;
- Health and Safety – Workers, Supervisors, Visitors, Neighbours, Public;
- Wastes Management – Construction phases waste management plan;
- QA/QC Programmes – independent QA/QC programmes to validate contract works; and
- Aftercare Management – Maintenance, monitoring, reporting,

Construction Period

It is planned to commence dump site rehabilitation activities as early as January 2009. This early phase will include a new management regime for the landfill operations, surveys and investigations and some waste stream diversion earthworks to better organise the existing site arrangements.

At this stage it is difficult to fix a precise timeframe for the completion of rehabilitation activities. A best estimate at this time is of the order of five (5) years.

Investigation of Dump Sites

As previously mentioned, ADWMC plans to introduce new controlled management processes at existing dump sites and landfills throughout the Emirate of Abu Dhabi. As part of this process, an experienced company or companies will be contracted to investigate and characterize existing dump sites and landfills.

The dumpsites, located throughout the Emirate of Abu Dhabi, have received a mix of waste streams over more than twenty (20) years, including, but not necessarily limited to, municipal solid waste, construction and demolition (C&D) waste, treated medical waste, animal wastes, liquid and solid hazardous wastes and non-hazardous industrial and commercial wastes. All of the sites have developed primarily as uncontrolled dump sites, with no engineering controls at the sites, nor any formal records of the quantities and characteristics of the waste dumped at the sites. The investigation and characterisation of the dump sites will be the first stage in producing definitive recommendations for the closure and rehabilitation of the dump sites.

Scope of Work

The following Scope of Work is to be expected as part of this Project:

- Compile and collate relevant available background information relating to each individual dump site;
- Undertake topographic and aerial surveys of the sites in order to establish the physical extent of the landfilled wastes and their relationship to the surrounding desert surfaces, including the establishment of a network of permanent benchmarks to co-ordinate future rehabilitation activities;
- Conduct appropriate subsurface investigations (intrusive and/or geophysical) to establish definitively and accurately the thickness and characteristics of the wastes across the whole of the area occupied by waste materials;
- Document (log) all subsurface investigations to acceptable international standards in order to record the different types of materials intersected and to establish the locations and characteristics of different types of wastes across the whole of the area occupied by waste materials;
- Establish the elevation of groundwater, and the direction of groundwater flow, beneath and adjacent to the landfilled wastes, through the establishment of a network of permanent groundwater monitoring wells;
- Establish the presence, quantities, pressure and characteristics of any landfill gasses present within and adjacent to the landfilled wastes, through the establishment of a network of permanent landfill gas monitoring wells;
- obtain representative samples of waste materials, and conduct appropriate laboratory assessments and analysis, in order to establish and characterize the type and extent of contamination of dumped waste materials;
- Obtain representative samples of sub-waste and surface soils, and conduct appropriate laboratory assessments and analysis, in order to establish and characterize the type and extent of contamination beneath, and adjacent to, the landfilled wastes; and
- Obtain representative samples of groundwater, and conduct appropriate laboratory assessments and analysis, in order to establish and characterize the type and extent of contamination of groundwater beneath, and adjacent to, the landfilled wastes.

Field investigations will be designed to determine the full spatial extent and characteristics of any contamination associated with, and derived from, the land-filled wastes.

4. Waste Management Strategy Workshop

The ADWMC held a workshop on 1 June 2008 to introduce the Abu Dhabi Waste Management Center and the development of the Waste Management Strategy with intention of gaining expert feedback from the participants and further inform the development of the strategy. The full day event was very successful with much useful feedback and overall positive participation. Through a series of tailored questions and working groups organized around business functions/sectors, common themes and directions were identified:

Education

- Critical to success in most issues
- Education covers many aspects:
  - Employees of offices
  - Maids
  - School children
  - New industrial processes
  - Legal requirements
  - Government procedures
- Can include waste behavior, appropriate services, preferred products and enforcement
- Must be integrated into other programs and aspects of life
- Should begin immediately as the education process is long term

Government Leadership

- Good facilities is the beginning
- Need for strong enforcement of laws
    - Litter, dumping, licensing
- Buying recycled products, training employees, good waste practices and strategic sites for facilities
- Need to provide a personal commitment and set example from the leaders of society
- Facilitate market development
- Develop reliable data
- Provide financial incentives, e.g. levy on plastic bags, deposits on containers, rewards for good performance and fines for poor

Partnerships

- Many agencies are interested in better waste management. ADWMC needs to coordinate and add value to green building, MASDAR, ZonesCorp, Municipalities, etc.
- Industry assist each other with experiences, sharing facilities and trading wastes
- Chamber of Commerce and other groups should be included where they can assist
- Public support is integral to changing culture of disposal and non-compliance
- All sectors must want a cleaner Abu Dhabi – no one sector or agency can or should do it alone

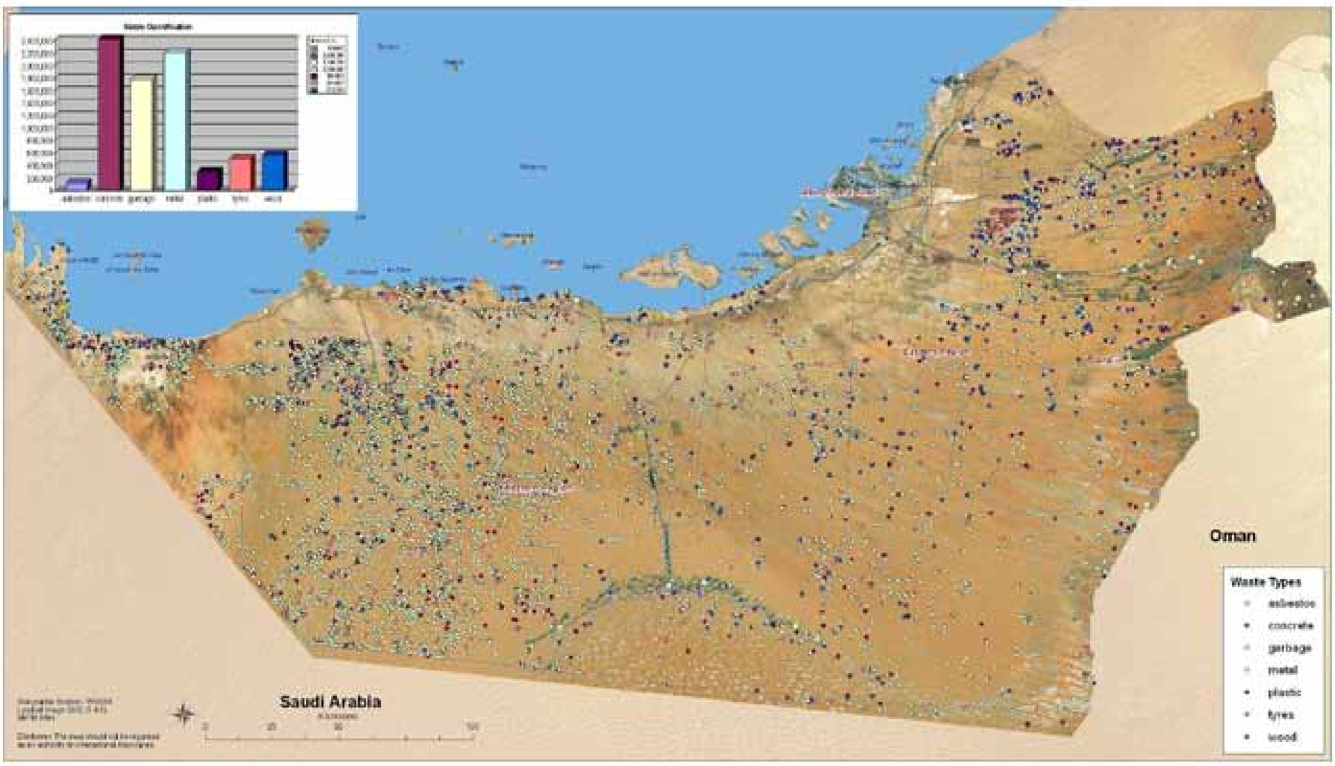
5. Waste Locations Aerial Survey

In 2007, EAD had assigned a contractor to conduct a wildlife survey using aerial surveys. As part of this survey, it was discovered that the non-urban areas of Abu Dhabi Emirate were littered with waste, and as a response, a waste survey was conducted by the Environment Management Section using the same method of aerial surveys for the entire Emirate of Abu Dhabi. X,Y coordinate locations were captured for all solid waste observations and classified according to:

- Asbestos
- Concrete
- Garbage
- Metal
- Plastic
- Tyres
- Wood

The Waste Locations figure on the following page illustrates the distribution of these wastes as well as the total quantity estimated throughout the survey.

Waste Locations



6. Air and Noise Quality Management[1]

In late 2007, EAD signed an agreement with the Norwegian Institute for Air Research (NILU) to outsource EAD air quality management activities for the period 2008-2012. This initiative hopes to reduce harmful air emissions and ensure better air quality for coming generations for the Emirate of Abu Dhabi.

The scope of work for this project in the coming five years focuses on the priorities for noise and air quality management including a comprehensive survey of noise levels in the Emirate for which a strategic noise map for Abu Dhabi will be delivered. The noise mapping is due to commence in late 2008 and will be conducted over two years. Please note that occupational noise and vibration is not included as part of this project.

The outsourcing project will also be responsible for the management, operation and maintenance of the air and noise quality monitoring network currently operated by the EAD. This network includes 10 fixed and 2 mobile Air Quality Monitoring Stations (AQMS). The locations of the fixed stations are described below

The type of stations and the list of measured parameters recorded at each station are provided below:

[1]Please note that much information included in this section was extracted from http://www.ead.ae/en/?T=4&ID=3469

Table 1: Air Quality Station Data

Air Quality Monitoring Station	Parameters Measured	Type of Station
Al Ain Islamic Institute	SO_2, NO_x, NO, H_2S, O_3, PM_{10}, CH_4, Noise	Urban/ Residential
Kadejah School	SO_2, NO_x, NO, H_2S, O_3, PM_{10}, CH_4, Noise	Down town
Khalifa School	SO_2, NO_x, NO, H_2S, O_3, PM_{10}, CH_4, Noise	Urban/ Residential
Gayathi School	SO_2, NO_x, NO, H_2S, O_3, PM_{10}, CH_4, Noise	Down town
Bida Zayed	SO_2, NO_x, NO, H_2S, O_3, PM_{10}, CH_4, Noise	Urban/ Residential
Baniyas School	SO_2, NO_x, NO, H_2S, O_3, PM_{10}, CH_4, Noise	Urban/ Residential
Hamdan Street	SO_2, NO_x, NO, CO, PM_{10}, CH_4, BTEX, Noise	Road Side
Al Ain Street	SO2, NOx, NO, CO, PM10, CH4, BTEX, Noise	Road Side
Mussafah	SO2, NOx, NO, CO, PM10, CH4, BTEX, Noise	Industrial
Liwa Oasis	SO2, NOx, NO, H2S, O3, PM10, CH4, Noise	Regional Background

EAD Fixed Air Quality Monitoring Stations

The fixed stations can be divided into the following four categories based upon the parameters to be measured:

Table 2: Summary of Fixed Air Quality Monitoring Stations

Type of AQMS	Parameters
Urban background/ Residential (4)	NO_x, SO_2, H_2S, PM_{10}, O_3, CH_4, Noise
Down town (2)	NO_x, SO_2, H_2S, PM_{10}, O_3, CH_4, Noise
Road Side (2)	NO_x, SO_2, CO, PM_{10}, BTEX, CH_4, Noise
Industrial (1)	NO_x, SO_2, H_2S, PM_{10}, CH_4, NMHC, Noise
Regional background (1)	NO_x, SO_2, O_3, PM_{10}, CH_4, Noise

The central server and data acquisition system at EAD office in Abu Dhabi City is capable of collecting data from the remote stations via dedicated telephone lines.

A fixed meteorological station is operated immediately adjacent to each of the fixed air quality monitoring station. There are two types of stations: the 10 m tower and the 25 m tower. The measured parameters that are recorded at each station are listed below:

Table 3: Types of Meteorological Stations

Type of Meteorological Station	Parameters
10 m Tower - Weather Description	Wind speed / direction, temperature, temperature variation
25 m Tower - Atmospheric Characterization	Wind speed / direction, relative humidity, temperatures/vertical temperature gradients, net radiation, wind fluctuations or turbulence, precipitation, atmospheric pressure

In addition, two mobile stations are used for monitoring the air shed at various locations within the Emirate. The measured parameters recorded at these stations are described below:

Table 4: Summary of Mobile Air Quality Monitoring Stations

Mobile Station	Parameters
Air Quality	NO_x, SO_2, H_2S, PM_{10}, CH_4, THC, BTEX, CO, Noise
10 m Tower – Weather and Atmospheric Characterization	Wind speed / direction, relative humidity, temperatures/vertical temperature gradients, net radiation, atmospheric pressure.

As part of this project, a source emissions inventory including point, area and line sources will be prepared in addition to an assessment of the compliance of industries and areas with the relevant standards and guidelines. In addition, NILU will also help in developing a strategy to reduce Greenhouse Gas Emissions, as well as develop and determine sector specific emission limits for different sectors including power sector and transportation. NILU will also be responsible for establishing a state of the art Internet solution for on-line data presentation and dissemination of the ambient air quality in the Emirate around the clock utilizing all relevant data from the monitoring network and give different end-users their required information in an easy to use interface.

The project is a continuation of the Abu Dhabi Emirate-wide Air Quality Management Study initiated in 2002 to determine the impact of current and future development activities on the quality of ambient air in Abu Dhabi. The scope of work of the study included analysis of the emissions and dispersion of flue gases from industrial stacks and vehicular traffic in the Emirate.

The study subdivided into four distinct stages, the first of which constituted baseline data collection and assessment in collaboration with a multi-disciplinary, multi-sectoral technical team.

The second stage, in which NILU took part, comprised of analysis of the emissions and dispersion of flue gases from industrial stacks (point and area stationary sources) and the emissions from vehicular traffic in the Emirate by using internationally approved air dispersion models. The outcome of the second stage helped to steer the implementation of the third one, which comprised of the purchase, construction and operation of a Central Network System, and a fully equipped and functional Air Quality Management System.

The continuous operation and manipulation of the installed state-of-the-art system comprise the fourth and last stage of this project. Experience will be built throughout the previous stages and will continue throughout the life of the project to ensure maximum utilization of this invaluable planning and prediction tool.

PREFACE

The waste management and pollution control sector in Abu Dhabi Emirate is evolving rapidly. Since the first version of this paper was submitted at the end of December 2005, the wastes and pollution management sector in Abu Dhabi witnessed several developments, and is now poised to witness more developments on the short term. Instead of keep changing the paper to catch up with developments, recent changes (2006 – 2007) are explained below, and the body of the paper is kept mostly unchanged, so that it reflects the status of waste management and pollution control in Abu Dhabi Emirate as of December 2005 - 2007. Changes were introduced in the body of this revised version of the paper only to correct errors, delete sensitive information, or elaborate on certain issues as deemed necessary by reviewers of the paper. Appendices 2 and 3 were also updated to reflect steps and progress in paper preparation and review.

Major relevant regulatory developments that occurred in Abu Dhabi Emirate and UAE at large since December 2005 - 2007 include the following:

1. A new federal Ministry of Environment and Water was formed. It will, or is expected to take over responsibilities of the Federal Environmental Agency, Ministry of Agriculture and Fisheries, and Ministry of Energy (regarding the control of radioactive sources).
2. Abu Dhabi Sewerage Services Company (ADSSC), established in late 2005, is now in charge of the management of sewage treatment plants in the Emirate.
3. The regulatory responsibilities of Abu Dhabi Sea Ports Authority and Abu Dhabi Civil Aviation Authority were assigned to a new Department of Transportation, and their operational responsibilities were assigned to two new government-owned com panies.
4. The federal Ministry of Communications was abolished.
5. Abu Dhabi Services Coordination Department was established, and may have a role in supervising waste management projects and services.
6. Major developments in the sector that occurred over the same period include:
7. Mussafah transfer station and green and municipal compost plants were closed, and an environmental permit was granted for removing above-ground structures at their site. Municipal solid waste is now being taken directly to Al-Dhafra landfill. Construction of a temporary green compost plant and a temporary transfer station was initiated at Mafraq. A tender was announced by Abu Dhabi Municipality to establish a new landfill and a new municipal compost plant.

8. Abu Dhabi Municipality informed of plans to establish a number of municipal solid waste facilities in the Western Region, including landfills at Madinat Zayed and Ghayathi, compost plant at Madinat Zayed, and sorting and transfer station at Madinat Zayed, Mirfa and Silaa.
9. The medical wastes management tender announced by GAHS in 2005 was reviewed by the Waste Privatization Committee, and a new concept for medical and hazardous waste management was pre pared by the committee and reviewed by EAD. The concept provided projections of hazardous waste quantities, recommended new facilities to be established and recommended interim solutions until then (through improved management of the existing landfill at Al-Dhafra).
10. Al-Ain Municipality started to plan for privatizing the operation of their newly established waste facilities. They also started planning for establishing a new double lined landfill.
11. Mubadala Company has been tasked with establishing an industrial area at Taweelah, northeast of Abu Dhabi City, to house heavy and other industries and a major port. The Department of Planning and Economy also announced intention to establish 15 new special economic zones.
12. A major urban development scheme was announced by Abu Dhabi government, for Lulu Island, just off the corniche of Abu Dhabi Island. Other large urban development schemes are expected for areas to the east and west of the island.
13. Recently acquired information from ADSSC about design capacities of sewage treatment plants was used to amend the relevant table (Table 3.2.1-C).

1 INTRODUCTION

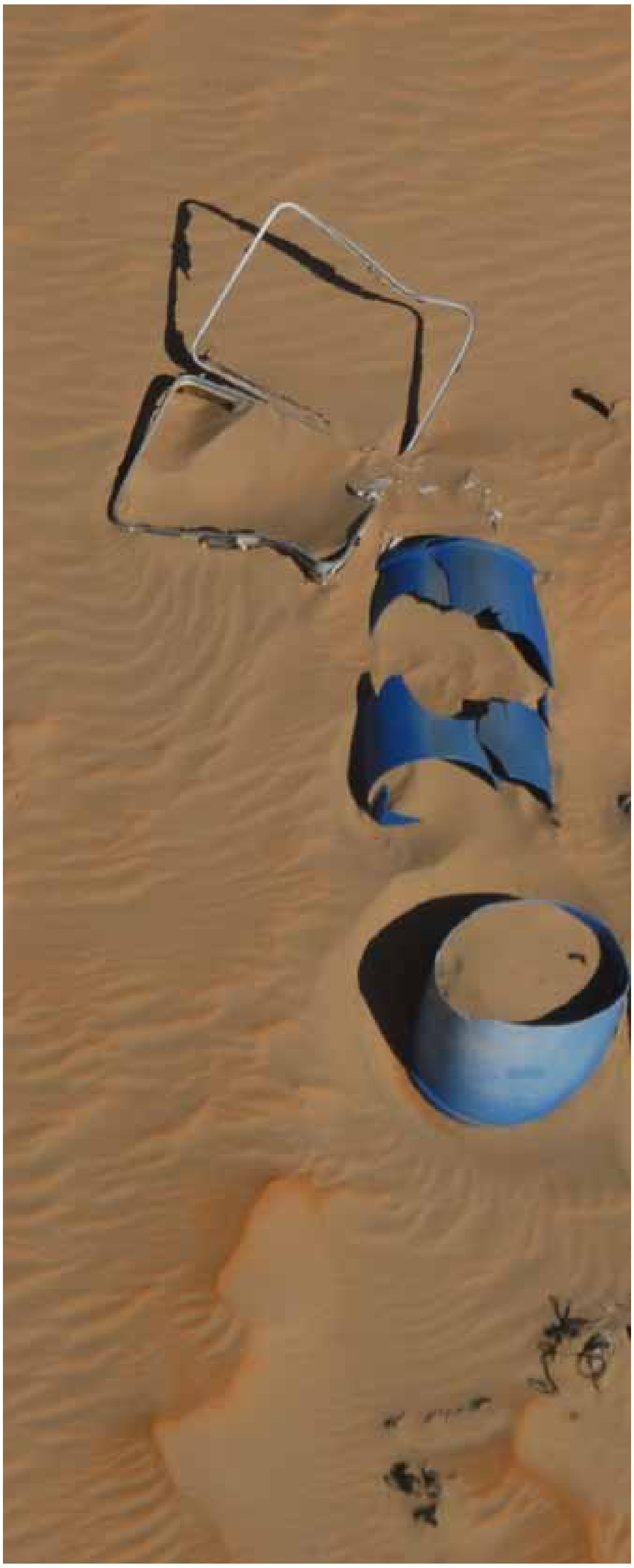
The population of Abu Dhabi Emirate has increased from about 15,000 in the mid 1950's (SPC, 1999; p.15) to more than 1,250,000 in 2003, concentrated in the Greater Abu Dhabi Area (about 847,000), greater Al-Ain City (411,000), and several smaller towns and villages in the Western Region (Madinat Zayed, Ghayathi, Mirfa, etc.). This rapid population growth was associated with urbanization, industrialization and economic diversification, and all were promoted and facilitated by the growth and revenues of the oil sector. Moreover, the Emirate is about to witness an even larger growth, considering the continued revenues from the oil sector and the many proposed housing and tourist developments (e.g. by Al-Dar and Sorouh Companies and Abu Dhabi Tourism Authority, at Al-Raha Beach, Al-Reem Island, Saadiyat Island, etc.). There are also plans to establish new industrial areas, e.g. at Al-Ain and south of Mussafah. These aspects are discussed in more detail in the companion sector paper on Population, Development and Economy.

Growth of urban, industrial, service, commercial, and other economic sectors is usually associated with increased generation of wastes and emissions of all types: Solid, liquid, domestic, commercial, agricultural, medical, hazardous, and non hazardous wastes, as well as emissions to air. These wastes and emissions, if not controlled / managed properly, may lead to significant health problems and impacts on ambient environmental quality.

This paper will present available knowledge about sources of pollution and types and quantities of wastes generated in Abu Dhabi Emirate and their management, and about levels of key pollutants in the local environment, notably in air. It will highlight the Emirate's previous efforts and future plans for controlling / managing pollution and wastes and reducing their impacts, and challenges still facing the Emirate in these fields. Additional complimentary information is contained in the sector papers on groundwater and marine environment.

The present paper reflects the status of waste management and pollution control aspects in Abu Dhabi Emirate as of December 2005.

2 OVERVIEW OF THE SITUATION IN ABU DHABI



2.1 Background

Since mid 1 960s, municipalities of Abu Dhabi, Al-Ain and their field offices (or sub-municipalities) were responsible for the overall management of wastes in Abu Dhabi Emirate, except for those generated by the oil sector. The latter were mostly managed by the oil companies. However, recent legal and organizational developments in the Emirate charged the Environment Agency – Abu Dhabi (EAD) with key regulatory and enforcement powers in the waste sector as well as in environment protection in general (Section 2.2).

Progressively, the municipalities established networks and plants for collecting and treating domestic discharges, and used the resulting treated effluents for irrigation. To protect the treatment plants, liquid wastes containing hazardous constituents were required to be treated to certain standards before discharge into the sewerage network.

Municipalities also established compost plants, transfer stations and simple landfills for domestic solid wastes, together with compost plants for green wastes. In view of the rapid industrialization and economic diversification from the one hand, and the lack of proper disposal facilities for hazardous wastes from the other, certain types of hazardous wastes gradually found their way into the landfills, although they are not designed for this purpose. Inability of landfills to receive hazardous wastes prompted oil companies, being the largest single producer of industrial wastes in the Emirate, to establish own facilities for hazardous waste handling and disposal.

Management of medical wastes witnessed changes over time. For several years, medical wastes were disposed of by incinerators at the main hospitals. Being old, located within urban areas, and performing below today's internationally recognized standards, most hospital incinerators were gradually closed and infectious wastes (which constitute the bulk of the medial wastes) were diverted to two private facilities for treatment by non-incineration techniques.

Environment protection, pollution control and waste management efforts were boosted in UAE at large, as well as in Abu Dhabi Emirate, by the passage of federal law (24 of 1999) and its executive byelaws, which were adopted in 2001. The law and its byelaws provided several important regulatory elements related to discharges, emissions and wastes. In addition, they regulated hazardous materials that were not federally regulated before. They also regulated agrochemicals, including pesticides, that were previously regulated by laws and orders enacted by the Ministry of Agriculture and Fisheries (MAF).

Similarly, the management of radioactive sources/materials was boosted on the federal level by the passage of federal law (1 of 2002) and the adoption of its executive regulations by the Ministry of Energy (formerly Ministry of Electricity and Water, MEW), which was named in the law as the federal competent authority for the control of radiation sources. Before then, radioactive sources/materials were managed at the federal level by the Civil Defense under their general statutory authority to protect the population from risks and dangers posed by materials, premises or vehicles, or accidents involving them.

Gradually, the private sector started to play an increasing role in waste management, especially in the transportation of wastes generated by industries and health-care facilities. Recently, Abu Dhabi Municipality (ADM) outsourced operation of its sewerage network and treatment plants, but retained ownership of these facilities. ADM also outsourced the collection and transportation of municipal solid wastes from most of Greater Abu Dhabi and the Western Region. In addition, some private companies started to establish facilities for recycling certain types of non-hazardous wastes (e.g.. the more profitable paper, cardboard, and plastic wastes) and for the handling of certain types of hazardous wastes. Notable among the latter are the two facilities for the treatment of infectious medical wastes and some facilities for the recovery of waste oil.

The many problems facing the waste sector lead concerned bodies to initiate studies and projects to rectify the situation. Both Al-Ain and Abu Dhabi Municipalities commissioned studies to enhance solid waste management in their respective regions and to plan new facilities for the disposal of hazardous and non-hazardous solid wastes. Construction of some of the envisaged facilities is already underway. ADNOC Group Companies also established a facility for temporary storage of their hazardous wastes and started a project to provide proper disposal facilities. And Abu Dhabi General Authority for Health Services is preparing for a tender for provision of modern facilities for the disposal of medical wastes.

More importantly, year 2005 witnessed some important legal and organizational developments (discussed below).

2.2 Legal and Policy Framework

Chronological development of environmental policies and legal instruments in Abu Dhabi Emirate and the corresponding organizational bodies responsible for their implementation can be outlined as follows (EAD (2004c, EAD Annual Reports, and other sources):

1975 A Supreme Council of the Environment is set up by the Ministerial Board to address environmental concerns in the UAE. This marks the official start of environmental protection activities in the country.

1993 The Federal Environmental Agency (FEA) is established by federal law (7 of 1993). It overtook all environment-related federal activities from the Supreme Council of the Environment.

A Food and Environment Control Center (FECC) is established at Abu Dhabi Municipality (ADM) by law (3 of 1993). Its functions included environment protection.

1994 Abu Dhabi Executive Council establishes an Environment Protection Committee headed by the Undersecretary of ADM, to oversee environmental concerns in the Emirate.

1995 FEA starts preparation of UAE environmental strategy.

1996 The Environmental Research and Wildlife Development Agency (ERWDA) is established by law (4 of 1996) to supersede the Environment Protection Committee. The law and its amendment (Law 1 of 1997) charge ERWDA with many environmental functions.

1997 Law (6 of 1997) establishes a Food and Environment Control Center (FECC) at Al-Ain Municipality, similar to that at ADM.

1998 Abu Dhabi Executive Council passes Law (4 of 1998) on management of medical wastes, as suggested by ADM.

1999 Federal environmental law (24 of 1999) is enacted.

ERWDA holds first workshop for development of Abu Dhabi 5-year Environmental Strategy and action plan. The strategy comprises six strategic goals, and its action plan is developed over 2000 and 2001.

2000 ERWDA is designated by the Executive Council (in November, session 23/2000, Decision 31) as the "competent authority" in Abu Dhabi Emirate for environment and wildlife issues.

2001 FEA publishes UAE federal environmental policy and action plan.

Council of Ministers (Decision 37 of 2001) approves four executive regulations (or byelaws) of the federal environmental law:

- Handling of Hazardous Materials, Hazardous Waste, and Medical Wastes (incorporating all provisions of Abu Dhabi law 4/1998 on the management of medical wastes).
- Assessment of Environmental Effects of Establishments.
- Protection of the Marine Environment.
- Pesticides, Agricultural Additives and Fertilizers.

Two other byelaws / regulations are pending the Council's approval:

- Protection of Air from Pollution Effects.
- Management of Protected Areas.

2002 ERWDA holds a second workshop (in April) to present, finalize and approve the Abu Dhabi Strategy and Action Plan

Law (1 of 2002) charges the Ministry of Electricity and Water (MEW, now the Ministry of Energy) with protecting the population from hazards of ionizing radiation. MEW approves an executive regulation for implementing the law.

2004 ERWDA publishes a revised Abu Dhabi Strategy and Action Plan (2003-2007) and starts planning for a (2005-2010) strategy emphasizing on sustainable development.

Al-Ain Municipality cancels plans to establish an environment protection section at its FECC. ERWDA establishes an office in Al-Ain.

MAF Decision (193/2004) bans entry into the UAE of some industrial chemicals and additional pesticides.

2005 Law (2 of 2005) establishes Abu Dhabi Food Control Authority and cancels environmental functions of predecessor FECCs.

Decision by the Council of Ministers names FEA as the competent federal authority for implementing law (1 of 2002), instead of MEW.

Law (16 of 2005) renames ERWDA as the Environment Agency – Abu Dhabi (EAD) and re-iterates and strengthens its responsibilities contained in laws (4 of 1996) and (1 of 1997). It cancels law (2 of 1999) related to the management of fertilizers and pesticides.

Law (21 of 2005) on waste management sets responsibilities of EAD and other concerned parties in waste management. It cancels law (4 of 1998) on management of medical wastes.

Three Abu Dhabi-wide committees are established (one by the Executive Council and two by EAD) to oversee issues related to waste management.

In Abu Dhabi Emirate, wastes were managed for a long time based mostly on local orders and policies enacted by the respective concerned parties, *e.g.* by the municipalities and ADNOC, rather than by laws and strategies on the emirate- level. The same is also true for environment protection activities, which were affected by ADNOC for the oil industry sector and by ADM Food and Environment Control Center (FECC) for the non-oil sector. Al-Ain Municipality also had plans to establish a second FECC to oversee environmental protection activities in areas under its jurisdiction.

This situation started to change recently with the passage of a number of federal and emirate-wide laws and / or regulations, as explained above. Waste management and environment protection work in Abu Dhabi Emirate are governed at present mainly by the following legal and policy instruments:

1. Federal environmental law (24 of 1999) and its executive byelaws issued in 2001, including the bylaw on the "Handling of Hazardous Materials, Hazardous Wastes and Medical Wastes". The federal law and byelaws are implemented on the federal level by the Federal Environment Agency (FEA) in cooperation and coordination with designated competent authorities in the respective emirates.
2. Law (16 of 2005) that empowers EAD as the competent authority in Abu Dhabi Emirate for implementing the federal environmental law. EAD's scope of work covers, among other things, the management of wastes and hazardous materials,

the permitting of projects and facilities likely to affect the environment, and environmental monitoring and enforcement.

3. Federal law (1 of 2002) and its executive byelaws on protection from hazards of ionizing radiation. The law and its byelaws are to be implemented on the federal level by the Federal Environment Agency (FEA) in cooperation and coordination with designated competent authorities in the respective emirates.

4. Law (21 of 2005) on waste management, which further clarified responsibilities of EAD and other concerned authorities (CAs) in waste management. This law is "a general framework law that provides a good foundation for modernization and further legal restructuring" of the Abu Dhabi waste management sector (Fichtner, 2005a, p. p. 3-2). It also allows for the finance and cost-recovery of the waste management services. But the law, by itself, is too general and its implementation requires the development of more specific regulations and legal and policy instruments (ibid.).

5. Abu Dhabi current strategy for the years 2003-2007, which places much emphasis on waste management and environment protection. Abu Dhabi's next strategy is being planned for the years 2006 to 2010, and will be announced early in 2006.

6. Cancellation of a number of predecessor Abu Dhabi laws, including No. 3 of 1993 (on establishment of FECC at ADM), 4 of 1998 (on management of medical wastes) and 2 of 1999 (on management of fertilizers and pesticides).

7. Decision of the Executive Council in 2005 that appointed Abu Dhabi Water and Electricity Authority (ADWEA) to manage the sewerage network and sewage treatment plants.

Three committees were established in 2005 at the Emirate level for different purposes, one by the Executive Council and two by EAD.

One of the two committees set by EAD reviewed drafts of laws and bylaws prepared by a consultant for Abu Dhabi Municipality, and concluded its work with the passage of a draft of law (21 of 2005). The second committee set by EAD includes members of other concerned bodies (Abu Dhabi and Al-Ain Municipalities, ADWEA, ADNOC, and GAHS), and aims to oversee the management of medical and hazardous wastes throughout the Emirate.

The committee set by Abu Dhabi Executive Council is to formulate a strategy for the privatization and improvement of waste management services in the Emirate, with emphasis on Greater Abu Dhabi and the Western Region. At present the committee includes EAD, Abu Dhabi Municipality and Mubadala Company, and is assisted by a private consulting office. Work and achievements of this committee are discussed in more detail in Section 3.1.1.

2.3 Role of EAD

EAD is implementing its role in environmental protection and waste management, as dictated by currently applicable legal and policy instruments (Section 2.2), through several functions, including:

1. Environmental permitting of projects, facilities and activities likely to affect the environment. This is performed through in-house procedures that are based on the federal environmental law and other relevant federal and local laws and regulations. In 2005, up until November, first-time environmental permits were granted to 127 new projects, facilities and activities and to 48 existing facilities and activities, and 339 permits were renewed. Permitting activities involved the review of 8 EIA studies, 9 preliminary environmental reviews, 5 construction environmental permits, 29 environmental baseline audits and 33 other studies. Environmental permits were also issued to 15 handlers of radioactive materials, 27 handlers of pesticides, and 54 handlers of other chemicals and hazardous materials (EAD, 2005i).

2. Enforcement of environmental laws and regulations, mainly through inspection and auditing. In 2005, up until November, more than 1400 inspections were performed by EAD staff for various facilities and purposes, and 29 major industries were audited by third party consultants. Industries spent more than 14 million AED to correct malpractice related to air emissions alone.

3. Environmental monitoring. In addition to a comprehensive air quality management project, EAD has initiated marine environment quality monitoring activities, and the Executive Council has approved a soil classification project covering the whole of Abu Dhabi Emirate. Permitted facilities are required, where warranted, to monitor quality of their air emissions, liquid discharges and solid wastes and to submit data to EAD. In addition, relatively large data sets are contained within EIA and baseline survey reports submitted by consultants as part of the permitting process.

4. Crisis management, especially with regards

to environmental accidents and incidents, in cooperation with other concerned parties. A consultant shall be commissioned shortly to review the existing situation and available capabilities, and to recommend a comprehensive strategy and a state-of-the-art centre for crisis management.

5. Management of hazardous materials and radioactive sources in cooperation with other parties, mainly through permitting of handlers, issue of import permits, and monitoring entry of chemicals and hazardous materials through customs point of entry in Abu Dhabi Emirate (about 32,000- shipments to date, mostly through Guwaifat).

6. Participation in implementation of some international initiatives and conventions, *e.g.* Clean Development Mechanism (CDM) and Cleaner Production (CP).

7. Waste management (next).

EAD's role in waste management is being / to be implemented through several functions, including:

- Permitting of environmental service providers (ESPs, i.e. private companies involved in waste collection, treatment and disposal, cleaning services, etc.). ESPs permitted by EAD until November 2005 are distributed as follows:

Field	Number
Medical (infectious)waste	2
Used oils	10
Non-hazardous solid and liquid waste	12
Asbestos removal	2
Paper	3
Industrial wastewater	1
Pharmaceuticals	1
Paints	2

- Preparation of Abu Dhabi-wide guidelines and codes of practice.
- Approval of waste management plans, guidelines and codes of practice set by the concerned authorities (CAs).
- Permitting of waste treatment and disposal facilities, whether private or government.
- Enforcing the use of a transport manifest to track movement of hazardous waste shipments.
- Inspection / auditing of waste generators and handling facilities, and investigation of complaints.
- Coordination with other concerned bodies.

To enable it to carry out all its required functions related to waste management, EAD is planning to establish an in-house unit for supervising the implementation of law (21 of 2005), in coordination and cooperation with other concerned authorities.

2.4 Definition of Hazardous Waste

UAE federal environmental law (24 of 1999) provides the following definitions:

- Hazardous Wastes: Residues or ash of different activities and operations containing properties of hazardous substances.
- Hazardous Substances: Solid, liquid or gaseous substances having properties harmful to human health or adverse impacts on the environment such as toxic substances, explosives, flammable or ionizing radioactive substances.

The federal byelaw on the "Handling of Hazardous Materials, Hazardous Wastes and Medical Wastes" further provides:

- A list of hazard properties, which is identical to the list of hazard properties adopted by the UN for characterizing dangerous goods and by the Basel Convention for characterizing hazardous waste.
- A list of hazardous wastes by source streams and by type of content, which is identical to the list of hazardous wastes adopted by the Basel Convention, except for four waste streams related to medical waste, and with the omission of the Y- codes assigned by the convention. Nevertheless, this byelaw treats medical wastes as hazardous wastes.

Building on the above, EAD prepared a guidance document on hazardous waste management (EAD, 2004a) that adopted the Y-codes classification system of the Basel convention, including its codes for medical wastes. The document also adopted Basel Convention classifications of waste recovery and disposal methods (R and D codes, respectively), a waste transport manifest system utilizing these various codes, and a system for quarterly reporting of waste quantities.

As pointed by Fichtner (2005a), the Y-code waste classification system is not easy to implement in practice, and EAD is seeking, in coordination with other concerned parties, to develop a more practical system. (*e.g.* comparable to the European Waste Catalogue, EWC).

3 COMPONENTS

3.1 Solid Wastes

3.1.1 Municipal Solid Waste

Definition

Municipal Solid Waste (MSW) is defined as comprising of the following types of solid waste (Fichtner, 2005a; p. p. 4-3):

- Household (residential, domestic) waste: Waste from individual households, excluding hostels, hotels, boarding houses, and similar commercial enterprises.
- Commercial waste: Waste that is similar in composition to household wastes and collected with the same collection system.
- Bulky waste: Large items of household or commercial waste (e.g. furniture, electronic scrap, A/C units).
- Market waste: Commercial waste and litter from market places.
- Street sweepings.
- Animal slaughterhouse wastes: Offal or other animal wastes from slaughterhouses.
- Green waste: Organic waste that is generated by gardening and forestry activities in public parks, gardens and other green areas.
- Public waste: Litter from public areas and manual street sweepings including emptying of public waste baskets.

Not included in this definition are industrial hazardous wastes, agricultural wastes, sewage sludge, hospital waste, construction and demolition waste, and radioactive waste.

Although green wastes are included in the above definition of municipal solid waste, they will be treated in this paper in a separate section together with similar organic wastes from agricultural production.

History

Municipal solid wastes have always been managed and controlled by the municipalities, which were also responsible for waste collection, transfer, segregation, treatment and disposal. Management relied mostly on the use of transfer stations (where wastes are also segregated), compost plants, and landfills. However, the approaches, programmes, facilities and processes used evolved greatly over time, facilitated by studies from private consulting offices.

ADM carried three consulting studies for enhancing its management of municipal and hazardous solid wastes (ENTEC, 1995; 1998a; Globex-City Consult

2004), but little developments has been implemented on the ground until very recently.

Al-Ain Municipality also commissioned a consulting study (ENTEC, 1998b) that aimed to improve its management of household, commercial, agricultural, bulky, industrial, hazardous, and construction and demolition wastes. The study aimed to achieve the following, of which several have been implemented to some extent:

- Collect data and assess the existing situation.
- Formulate a Solid Waste Management Strategy for Al-Ain Region, including waste minimization and recycling schemes and awareness programmes.
- Upgrade performance of the existing compost plant and other waste treatment and disposal facilities.
- Establish new waste facilities (transfer stations, a sorting station, a lined landfill, and a hazardous waste incinerator).
- Assess current waste management procedures and organizational structures, and put recommendations for improvement.
- Assess costs of waste services and increase their cost effectiveness.

As partly explained in Sections 2.1 and 2.2, years 2004 and 2005 witnessed several legal and regulatory developments related to solid waste management, notably:

- Combining all municipalities under a newly formed Department of Municipalities and Agriculture, thus enhancing possibilities for formulating Emirate-wide waste policies.
- Combining compost plants in Abu Dhabi and Al- Ain under one management, thus providing opportunities to reduce operational costs and harmonize policies and methods for the production, marketing and use of compost.
- Passage of law (16 of 2005) on the re-organization of EAD and law (21 of 2005) on waste management.
- Formation of a committee to prepare and implement a strategy for the management of solid wastes and for the privatization of waste services and facilities.

The latter committee is implementing a project aiming at the "Establishment of a successful solid waste management concept based on private participation" (Fichtner, 2005a). More specifically, this project aims to achieve the following objectives with emphasis on services offered by Abu Dhabi Municipality (ibid.).

- Develop a concept for solid waste management in Greater Abu Dhabi.
- Recommend / set up policies, master plan, organizational structures and financial and legal instruments required for improving waste management and for the privatization of waste management services following BOO (Build, Own, Operate), BOOT (Build, Own, Operate, Transfer) or other models.
- Establish a tariff system.
- Fast-track the development of key facilities required for improving solid waste management, treatment and disposal in the emirate. The project shall develop facilities providing permanent longterm solutions for main waste streams, as well as facilities providing quick, temporary solutions until then.
- Prepare, tender, and manage contracts with the private sector for the design, construction and operation of the required treatment and disposal facilities.

This project started on June 5, 2005, and will be executed in phases, of which only phase 1 has been completed (Fichtner, 2005a). This phase (Status Quo Analysis) mostly reviewed the existing situation as documented in available documents and previous studies, and collected specific additional data only where needed.

Some of the key regulatory outputs of this project so far include:

- A draft solid waste management policy for Abu Dhabi Emirate, to be endorsed / enacted by EAD.
- A proposed Standing Commission for Solid Waste Management, and a corresponding draft enabling law. A Standing Commission is considered the best option available at present for authorizing a single body with the management of relevant waste contracts with the private sector. The commission enabling law would clearly delineate responsibilities of EAD, the Standing Commission, and other concerned parties in tendering and contracting waste management projects, and in supervising contract implementation.

The project / committee expect privatization to enhance the performance of all facilities involved. However, the exact model of privatization to be adopted in Abu Dhabi is still being studied.

The project / committee are concentrating on upgrading the performance of the existing waste facilities, especially the transfer station and compost plant at Mussafah and the landfill at Dhafra. Ultimately, new transfer station, sorting plant and landfill are expected to be established.

However, the future role of composting in municipal waste management is still being assessed, as is the need for a plant for municipal waste composting.

Sources and Quantities

Table (3.1.1-A) provides overall estimates of MSW quantities produced in Abu Dhabi Emirate as determined by consultants. Only indirect such estimates are available at present because only few waste disposal facilities routinely measure quantities of waste that they handle

Region / Municipality	Waste Generated		Source
	Type	Quantity (Base Year)	
Greater Abu Dhabi*	Municipal	1532 ton/day (2004)	Fichtner (2005a), based on reports of Abu Dhabi Municipality, and previous studies by Fichtner (2000) and Globex-City Consult (2000)
Western Region **	Municipal	303 ton/day (2004)	Fichtner (2005a), based on estimates by of Abu Dhabi Municipality, and previous studies by Fichtner (2000) and Globex-City Consult (2001)
Al-Ain Region	Household/ commercial	120,000 ton/ year	ENTEC (1998b), based on weighing of collection vehicles at the compost plant weighbridge.

Table 3.1.1A: Generation of Municipal Solid Wastes in Abu Dhabi Emirate

* Abu Dhabi Island, Mussafah, Shahama, Samha, Mussafah, Bani Yas, Al Wathba, Al-Khatem.

** Al-Sila, Al-Ruwais, Ghayathi, Al-Mirfa, Madinat Zayed, Liwa, Tarif, Delma Island, Sir Bani Yas Island.

Table (3.1.1B) summarizes waste composition in Greater Abu Dhabi area according to a waste characterization study, and compares it to an assumed waste composition for future design purposes. The assumed composition was based on a comparison with comparable countries and cities, to account for potential changes in waste composition (as new policies / procedures are adopted), and to ensure that future recycling plants can cope with a broad range of waste properties (Fichtner, 2005a).

Type of Waste	Percentage, According to	
	Characterization Study *	Assumed Composition **
Plastics	10.9	10-15
Paper / Cardboard	5.2	15-20
Organics (food and bio-waste)	73.7	40-50
Metal	2.1	3-5
Glass	3.5	3-5
Miscellaneous (including clothes, wood, household solid waste)	4.7	5-10

Table 3.1.1B: Waste Composition in Greater Abu Dhabi Area

* Globex-City Consult (2000; op. cit. Fichtner, 2005a)
** Fichtner (2005a)

Fichtner (2005a) forecasted MSW quantities in Greater Abu Dhabi and the Western Region up to 2025 based on:

- Estimates of current waste generation **(Table 3.1.1A).**
- Projected population growth.
- Forecasts of economic development.
- Changes in patterns of consumption and consumption behavior.
- Possible waste avoidance practices.

Three scenarios were calculated, a basic scenario as well as low and high scenarios. According to the basic scenario (which is most probable), waste generated in years 2010, 2015, 2020 and 2025 will amount (in tons / day) to about 2010, 2515, 3150 and 3950 in Greater Abu Dhabi, and to 384, 471, 577, 707 in the Western region, respectively.

ENTEC (1998b) predicted waste generation in Al-Ain region to increase from 120,000 tons/year in 1998 to about three times as much in 2015, concomitant with a population growth from about 245 thousand in 1995 to 775 thousand, assuming a rate of increase of 5.6% (1995 census data).

Overall Management Scheme:

Until very recently, approaches used by Abu Dhabi and Al-Ain municipalities for the management of municipal solid waste were only slightly different.

Some bulky wastes generated in Greater Abu Dhabi Area used to be taken to collection points and hauled directly to the landfill at Dhafra. All other MSW used to be directed to Mussafah transfer station and compost plant, where they were weighed by a weighbridge. The compo stable fractions of waste (including green waste, slaughterhouse waste, and part of the household waste) were directed to the compost plant, whereas non-compostable fractions (e.g. non-hazardous industrial waste and wastes in excess of the handling capacity of the compost plant) were reloaded onto large capacity transport vehicles in the adjacent transfer area and hauled for disposal at landfills (Fichtner, 2005a). This scheme is expected to change shortly in view of recent relevant regulatory and management developments in the Emirate.

Al-Ain compost plant and transfer station are located about 20 km southwest of Al-Ain City (DPE, 2005). The incoming waste is initially sorted by screens, magnetic separation and manual separation into organic waste (that is directed to the compost plant) and inert materials (that are taken to an adjacent dump site; Maunsell, 2004, p. p. 14). Collectively, the plant has been estimated to receive 120,000 tons/year of MSW, from which approximately 36,000 tons of compost are produced (ENTEC, 1998b).

In the Western Region, there are no recycling facilities, transfer stations or household compost plants, and the waste collected is transported directly to various dumping sites.

In addition, the private sector plays a role in the recycling of specific waste streams that are more profitable (*e.g. e.g.* paper and plastic).

Transfer Stations / Compost Plants

Municipal compost plants, which are usually operated in association with solid waste transfer stations, aim to (DPE, 2005):

- Achieve safe disposal of organic materials that constitute 50-55% of domestic wastes, thus eliminating the need for costly incinerators or landfills.
- Produce organic fertilizers for use in various greening and agricultural projects.
- Benefit from revenues generated from the sale of compost and other recyclable materials.

The first municipal compost plant in Abu Dhabi was commissioned in Mussafah in 1977. The compost plant comprised one line for composting, capable of handling 120 tons/day of municipal waste. Three similar lines were added in 1979 bringing total capacity to 480 tons/day. By late 2005, the plant received about 500-600 tons/d of household, commercial and institutional waste, 10 tons/d of slaughterhouse waste, and 10-30tons/d of sewage sludge. The output quantity of "city compost" was about 140-160 tons / day (DPE, 2005; Fichtner, 2005a). The composting process involved the following main steps (DPE, 2005):

- Reception facility, where truckloads from the city were weighed and emptied.
- Hammer mills to macerate large objects and increase surface area of wastes.
- Magnetic separator, to remove metallic objects.
- Cylinder for waste mixing and homogenization, with mechanisms for continuous aeration and odour suction and control. The resulting high temperatures would destroy pathogenic organisms. Where needed, water or sewage was added to maintain moisture at the required level (about 55%).
- Sieving to remove objects larger than 2.5 cm (sent to the landfill).
- Primary fermentation in triangular section windrows, each having a height of 1.5m, for 1 month, with the addition of water where needed. Each windrow was turned 4-5 times during this period.
- Maturation, in heaps 4 m high, for about 2 months.
- Sieving to remove particles larger than 1 cm.
- Gravity separation (to remove glass and sand articles).
- Packaging, if required.

The transfer station at Mussafah used to receive non-compostable waste, waste quantities exceeding the handling capacity of the compost plant, and all delivered waste quantities during outage of the latter plant. It was estimated to receive 270-480 ton/d of rejects from the compost plant and 50-220 ton/d of raw municipal wastes (Fichtner, 2005a). (See **Figure 3.1.1-A**)

Figure 3.1.1A: Waste Handling Operations at Mussafah Transfer Station

Al-Ain compost plant includes three lines, whereby lines 2 & 3 (both completed in 1987; throughput 137.5 tons/day each) employ a system different from line 1 (commissioned in 1978; throughput 200 tons/day). The composting process in line 1 (ENTEC, 1998b, Appendix 18) is identical in principle to that employed in Abu Dhabi Compost Plant, with slight differences in details. The composting process in lines 2 and 3 is different, involving the following processes (Maunsell, 2004, p. p. 14; ENTEC, 1 998b, Appendix 18):

- Shredding and screening of the organic material (to achieve optimal particle size for composting, about
- 2.5cm) followed by the addition (in a mixing drum) of sewage effluent from the adjacent sewage treatment plant (to adjust the moisture content).
- Composting by a negative pressure aeration windrow process. The compost is placed in elongated static piles, over perforated pipes, which draw air through the piles and aerate the compost. The temperature of the fermenting mass is controlled by the air flowing through it and by spraying water from the overhead sprinkler system, which also maintains the moisture content. After three weeks, during which time the compost is regularly turned, the compost is removed to a maturation area. Here it remains for two months being subjected to aeration that is similar to but gentler than that used during fermentation.
- Processing in a rotation drum and screens, to regulate particle size and moisture content and remove solid particles (de-stoned), before being sold loose or packed in bags as fertilizer.
- Rejects from all operations are taken to the dump site.
- The air that is drawn through the composting mass during fermentation and maturation is passed over a water-cooled condenser (to remove water vapour), then through a compost filter (to remove malodorous constituents), before being exhausted to the atmosphere. The resulting black, foul smelling condensate has a high humic acid content and a very high BOD. In 1998, this noxious condensate could not be received by the sewage treatment plant and had to be land spread.

Although there are no information on its content of chemical contaminant's (such as heavy metals), municipal compost produced by Al-Ain plant was found contaminated with fragments of plastic and glass, due to ineffective segregation of these materials during proceeding (ENTEC, 1998b). Similar quality problems are expected with the compost produced by the Mussafah plant. Consulting studies (ENTEC, 1998b; DPE, 2005) emphasized that improving the quality of municipal compost would require effective schemes for waste segregation at source, which are not existent at the present. Alternatively, they recommended that waste separation / sorting facilities should be established.

Abu Dhabi compost plant was established when Mussafah was far from urban centres, and was anticipated to require decommissioning by the time urbanization reached the area (in about 20 years time). Now, the plant is at the heart of a bustling area for various uses, the quality of its compost is questionable, and its performance has come under criticism for the nuisance it is creating to the surrounding areas due to odours, litter and poor aesthetic impression (DPE, 2005; others). In October 2005, the Executive Council authorized closure of the Mussafah Compost plant and transfer station. Until permanent replacement facilities are decided, only a temporary transfer station shall be established and the waste shall be hauled directly to Al-Dhafra landfill.

Landfills

Greater Abu Dhabi area is served by one landfill at Al-Dhafra, some 60 Km away from Mussafah composting plant and transfer station, where there is no weighbridge and no recording of incoming waste quantities. Out of 1100 ton/day of generated MSW, the landfill is estimated to receive 450-730 ton/d (270-480 ton/d from Mussafah transfer station, including rejects from the compost plant, and 180-250 ton/d of bulky and other wastes; Fichtner, 2005a). The landfill also frequently receives some liquid wastes and some hazardous wastes, which create serious operational problems at the site, including a plume of increased salinity in underlying groundwater (ibid.; others).

A number of small landfills occur throughout the Western Region, including at Al-Ruwais, Madinat Zayed, Sir Bani Yas Island, Delma Island, Al-Sila, Hamim, Tharwaniya, Khanoor, Al-Mirfa and Ghayathi. Collectively, these landfills are estimated to receive 342-409 ton/d of waste (12-24 ton/d of rejects from green compost plants, and 330-385 ton/d of other municipal waste; Fichtner 2005a).

Until recently, Al-Ain Municipality had one major operational landfill at Zakher and four smaller landfills at sub- municipalities at Al-Wagan, Al-Hayer, Al-Khazna and Sweihan. In 1998, the five landfills were estimated to receive about 242,000 ton/ year of MSW. About 350,000 – 500,000 ton/year of agricultural wastes were also disposed of at the four smaller locations, or dumped at many informal disposal sites in the desert (ENTEC, 1998b):

Consulting studies (ENTEC, 1998 a, b; Globex-City Consult, 2000, 2001, 2002; Maunsell, 2004; Fichtner, 2005a) suggested that performance of Al-Dhafra landfill and landfills in Al-Ain region is below international standards in the following respects:

- Design and operating standards are inadequate.
- Lack of planned engineering approach.
- Staff are not trained or experienced in modern sanitary landfill practices.
- The health and safety of workers is at risk.
- Groundwater resources are potentially threatened by pollution.
- Agricultural organic wastes overwhelm the landfill system (which is especially true in Al-Ain region).
- There is lack of regulation and control (legislation) of waste disposal practices.
- Uncontrolled dumping of liquid and some hazardous wastes.
- Unsatisfactory practice of burning solid waste at the municipal dump site.
- Adequate closure and restoration of existing siteswill be required to secure them for the future.

To overcome these problems, and following recommendations by ENTEC (1998b), Al-Ain Municipality started a project that aimed to provide the following ((ENTEC, 1998b; Maunsell, 2004, p. 15):

- Transfer stations at Sweihan, Al-Hayer, Ramah, and Al-Wagen. Each station has a compaction machine having a capacity of 45 ton /h.
- A sorting station at SeehSeh Al Hemmah, west of the existing compost plant. The station shall receive wastes from Al-Ain City as well as from the transfer stations in the peripheral townships. The station has four conveyor belts each having a capacity of 15 tons/h and a design life of 10-15 years. Laborers stationed on both sides of the conveyor belt would separate the unwanted wastes. Organic-rich materials are diverted to the compost plant, recyclable wastes are collected and stored for further marketing, and the remaining unwanted materials are transported to the landfill site. On average, the station would handle 218,000 tons/ year.
- A new central single-lined landfill to serve Al-Ain and its sub-municipalities, in Suwaifi, 18 km west of the existing compost plant, near the eastern boundary of the existing municipality dump site. An area of 200 hectares have been reserved for this landfill (2.0 x 1.0 km), capable of receiving more than 7 million m3 (more than 5 million tons) of waste. The landfill is designed to be used in a number of phases (5 years each) with 2,408,000m3 capacity for each phase. The landfill life is 15-20 years.

Construction of the new landfill, transfer stations and sorting station is almost complete, and they are expected to be commissioned by mid 2006.

Abu Dhabi Municipality is also planning to establish a new landfill and, until then, to improve the operation of the existing landfill at Al-Dhafra (Fichtner, 2005a).

Recycling of MSW

Recycling in Al-Ain (ENTEC, 1998b) and elsewhere in Abu Dhabi occurs purely as a private sector function, and is completely driven by the economics of the chain of recycling (i.e. collection, handling, transfer, transportation and sale price).

Some private companies sort and recycle some home, commercial and construction wastes, including:

- Paper and card paper from home and commercial wastes.
- Metal structures, doors and glass from demolished buildings. .
- Wood and metals from construction wastes, and iron from demolishing works.
- Concrete blocks from demolishing works (Basically used in filling up and reclamation of land).

Recycling of industrial waste is almost entirely restricted to metal wastes, for which economics are favourable. There is also a market for waste oil. Otherwise, there is limited incentive for industry to reduce or recycle wastes, since tipping costs are effectively nil and transport costs are low (ENTEC, 1998b).

Recycling of tires requires special consideration. Large quantities of tires generated every year are stored at designated locations within landfill sites or on private lands (EAD, 2005d). Occasionally, tires are burned on site, sometimes to reclaim the constituent metals. Open burning would lead to unacceptable emissions, because of the complex composition of tires (*e.g.* rubber, sulphur, ozonates, fillers, mineral salts, etc.; EAD, 2005e) (See **Figure 3.1.1-B**). This practice should be stopped, and waste tires should be incinerated in proper incinerators, recycled as much as possible, or pulverized and the resulting powder used as a fill material or for other applications (ibid.).

For a viable recycling market, facilities need to exist to accept and process the recovered wastes (ENTEC, 1998). Recently, EAD has permitted some such facilities, including for the pelletizing of waste plastics, and recycling of marble and other construction materials. Sorting facilities planned by AAM and ADM will also play an important role in boosting the recycling market.

So far, there is effectively no recycling of household wastes on an organized basis, by municipalities or others, although some pilot and small scale schemes involving paper, cans, and glass are running. Informal recycling occurs via scavengers who hand sort waste, mainly cardboard and aluminium cans, from collection pins for onward sale to merchants. It also occurs for some wastes resulting from the compost plants (steel and aluminium cans, some glass) (ENTEC 1998b).

The success of waste recycling processes requires efficient systems for wastes segregation at source. It also requires a system of incentives, economic and otherwise. Possible schemes that can be implemented include clean materials recovery facilities, waste recovery banks, and kerbside collection schemes (ENTEC, 1998b).

(a)

(b)

Figure 3.1.1B: Tires (a) collected at a private collection site, (b) ablaze at a landfill site.

Issues, Trends, and Future Actions

Quantities of MSW are expected to increase significantly over the coming 15 years or so, concomitant with population growth and economic diversification.

The proposed new policy, strategy and organizational structures required for improving solid waste management should be developed and enacted as soon as possible. Under these directions, the private sector is expected to gradually play a greater role in the management of MSW.

Waste disposal practices at Al-Dhafra landfill and at landfills in Al-Ain region need to be improved. Some practices will have to be stopped (*e.g.* open burning waste, disposal of liquid wastes).

Problems encountered with the management of MSW in Al- Ain region are likely to be alleviated shortly when newly constructed facilities become operational. Alleviating corresponding problems encountered in Greater Abu Dhabi area will require more time, to design and build the required facilities.

Solving some problems requires strong schemes for waste segregation at source, *e.g.* by providing collection bins in public places for glass, paper, aluminium cans, etc.

Awareness programmes are required for the public and for industries to encourage waste minimization, recycling and the use of recycled materials.

3.1.2 Green and Agricultural Organic Wastes

Definition

- Green waste: Organic waste that is generated by gardening and forestry activities in public parks, gardens and other green areas.
- Agricultural organic waste: Fruits and vegetables that are wasted, either because of defects, or because of surplus production.

The two waste streams are addressed together because their methods of disposal are similar.

History

Wide-spread greening, afforestation and agricultural development in the Emirate lead to a large increase in the amount of green and agricultural organic wastes. To minimize environmental impacts of these wastes, a programme was initiated by Abu Dhabi Municipality to compost and re-use them in agriculture as fertilizers. The first plant was commissioned in Mussafah in 1995 and was followed by plants in other areas in the Western Region **(Table 3.1.2A)**. Al-Ain does not have units for green composting.

City	Commissioned	Nominal Capacity (Tons/ Year)
Mussafah	1995	40,000
Liwa	1999	36,000
Ghayathi	2001	20,000
Al-Khatim	2002	10,000

Table 3.1.2A: Green Compost Plants Established by Abu Dhabi Municipality

Source: DPE (2005)

Quantities

There are no available estimates of green and agricultural organic wastes produced within Grater Abu Dhabi Area and the Western Region, except for plant design capacities **(Table 3.1.2A)**.

In 1998, quantity of agricultural organic waste produced in Al- Ain region was almost three times its MSW (i.e. about 350,000-500,000 tons/year) partly because of wasted surplus agriculture products (ENTEC 1998b). At that time, wasted surplus agricultural products were mostly made of tomatoes (in the period December-March) and onions, alfalfa and cucumbers (April-May). Updates for these figures are not available. Informal recent information indicates that agricultural policies developed since then has almost eliminated this problem.

Management

The green compositing process is very simple, involving the following steps that are implemented using mobile equipment (DPE, 2005):

- Shredding of green waste into small pieces, during which process water is added to increase waste moisture to 60-65% and NPK fertilizer is added o enhance the fermentation process.
- Fermentation for 45 days in elongated heaps, each about 1 .5m high, together with tilling and irrigation every 3 days.
- Maturation, through storage for 15 days in 4-m high heaps.
- Screening, to remove large pieces of organic waste (that are re-composted).
- Packing.

The first green composting line established in Mussafah in 1995 was designed to convert 30,000 tons/year of agricultural wastes into 15,000 tons/year of green (or "farm") compost. Capacity was increased in 1998 to handle 80,000 tons/year of wastes producing 40,000 tons/

year of green compost (DPE, 2005). Before its closure in 2005, the plant handled about 200 tons/d of green, landscape and agricultural waste and produced about 80-90 tons/d (29000-33000 tons/year) of green compost (Fichtner, 2005a). Overall quantities of wastes handled and compost produced since commissioning of the various compost plants are summarized in **Table 3.1.2-B**.

Plant (Year)	Wastes Handled (tons)		Compost Produced (Tons)	
	Municipal	Agricultural	City Compost	Farm Compost
Mussafah (1977)	3,623,428	660,166	1,387,968	308,291
Liwa (1999)	-	287,396	-	126,057
Ghayathi (2001)	-	139,558	-	48,455
Al –Khatim (2002)	-	106,080	-	22,116
Total	**3,623,428**	**1,193,200**	**1,387,968**	**504,919**

Table 3.1.2B: Quantities of wastes handled and compost produced by the various compost plants managed by Abu Dhabi Municipality (1 977-2005).

Source: (DPE, 2005).

The green compost offers many advantages over the municipal compost, especially being high in organic content, clean of animal and plant pathogens, and clean of glass, metal, and plastic impurities. (DPE, 2005)

When the Mussafah transfer station and compost plant are closed by the end of 2005, a temporary green compost plant would probably be established near the planned transitional transfer station, followed by a permanent plant at a location that is still to be determined.

Because Al-Ain compost plant does not have units for green composting, green and agricultural organic wastes were disposed of at the four smaller locations, or dumped at many informal disposal sites in the desert. The Municipality was recommended to mix these vegetable and shredded horticultural (green) wastes and to compost the mixture using a simple low-technology solution, instead dumping them at the landfill (ENTEC, 1998b).

Issues, Trends, and Future Actions

There is need for better, recent estimates of the amounts of green and agricultural organic wastes produced in Abu Dhabi Emirate.

Excessive amounts of wasted agricultural products in Al-Ain in 1998 reflect agricultural policies of that period. Recent changes in agricultural policy are likely to have reduced these quantities significantly.

The green compositing process is very simple, and produces cleaner compost than municipal waste. The practice should be encouraged and continued to the greatest extent possible.

3.1.3 Construction and Demolition Waste

Definition and sources

Construction and demolition (C&D) waste is defined as non-putrescible waste materials that are generated in the normal course of construction and demolition processes. Generally, these materials are not water soluble and non-hazardous in nature (Globex-City Consult, 2002).

C&D wastes may be distinguished into five different types, associated with different sources / activities, namely (Fichtner, 2005a):

a) Excavation, which produces materials that are composed mostly of rock and soil, usually not contaminated.

b) Construction, producing wastes consisting of concrete spoils, bricks debris, scrap metal, demolition timber, glass, plaster, and plaster board. Construction wastes may also contain hazardous constituents from equipment maintenance (*e.g.* oil filters) or materials needed for construction (*e.g.* paints, solvents, glues, contaminated cloth, *etc.*).

c) Demolition, which generates either internal finishing that are removed before demolition, or demolition debris consisting of concrete, gypsum and reinforcement steel. Demolition wastes may also contain asbestos or wastes contaminated with other hazardous materials, depending on the building materials used and former utilization of the building.

d) Refurbishment of flats and houses, which produces wastes consisting of concrete spoils, bricks debris, scarp metal, demolition timber, glass, and plaster board. These wastes may also contain hazardous constituents from materials needed for refurbishment (*e.g.* paints, solvents, clues, contaminated cloths, *etc.*).

e) Road refurbishment, generating wastes consisting of asphalt, bituminous materials, sand and gravel from road layers.

In addition, initial site clearing operations may contain top soil and green materials. During handling, C&D waste may also become contaminated / mixed with municipal solid waste.

Quantities

In 1998, it was estimated that about 750,000-1,000,000 ton/year of C&D wastes are produced from Al-Ain region (ENTEC, 1998b).

Based on a limited one-week survey of shipments arriving at Al-Dhafra landfill, Globex-City Consult (2002) estimated that the landfill receives more than 1000 ton/d of C&D waste. Indirect estimates by Fichtner (2005a) of C&D waste reaching Al-Dhafra landfill produced a comparable number (920-940 ton/day; **Table 3.1.3-A**).

Management

C&D waste management is fairly well organized in Abu Dhabi Emirate, and is mostly carried out by private companies, as described below (Fichtner, 2005a; and EAD, 2005h; unless otherwise noted).

The majority of excavation materials that are not contaminated are used for landscaping and land reclamation both on-land and in coastal areas (**Figure 3.1.3-A**). The remainder is sent to the various dump sites.

Table 3.13A: Quantities of C&D waste from Greater Abu Dhabi

Waste Source	Waste Quantity (ton/d)	Basis for Estimation
Excavation	No need for estimation	
Road refurbishment	No need for estimation	
Construction	400	• Number of building permits granted. • Calculating utilizable surface area of the buildings • Applying an average factor in m3/m2 derived from different countries • Applying an average density of 0.6 ton/m3.
Demolition Mineral Waste	370	• Number of demolition permits granted. • Calculating utilizable surface area of the buildings • Applying an average factor in m3/m2 derived from model calculations • Applying an average density of 1.4 ton/ m3.
Demoli tion interior finishings	20 - 40	• Finishings account to 10-20% of the mineral demolition waste quantity. • Only 50% of this quantity goes to the landfill (the difference is re-used or recycled).
Refurbishment of flats and houses	10 - 25	• Number of refurbishment permits. • 1-2 skips (i.e. 5-14 m3) / refurbishment (average 7 ton/ refurbishment). • Waste density of 0.7.
Military and Police	80	10% of the waste estimated based on civilian construction and demolition permits (because police and military installations do not need such permits).
Total	920 - 940	

Source: Fichtner (2005a).

Figure 3.13A: Waste used at various reclamation sites, (3 pictures; LAD, 2005h).

During construction, few materials having high economic value are separated for recycling (*e.g.* plastic film from packaging, and scrap metal). However, most wastes get thrown through waste tubes into skips then transported to dump sites. Hazardous materials from the works (*e.g.* surplus paint, solvents, batteries) usually end up with this waste stream.

Demolition of buildings is usually carried out in two phases by specialized companies registered with the Municipalities. First, interior finishings are removed from the building. These materials are either (1) directly sold for reuse, (2) brought to premises of the demolition companies for later sale, reuse or recycling, or (3) transported to dump sites if no further use is possible. Concrete structures are then demolished following codes of practice that aim to reduce impacts of dust and noise on inhabitants of neighbouring buildings (*e.g.* by water spraying and by installing barriers). The steel contained in the demolition debris is removed to the extent possible for sale to scrap dealers. The remaining concrete blocks (with any remainder steel) are used for landscaping projects or sent to the dumpsites.

Asphalt removed from road refurbishment is mostly used by companies that mix it into new asphalt or by using it for new sub-bases.

Globex-City Consult (2002) observed significant variations in the composition of C&D waste reaching Al-Dhafra landfill, with aggregate materials (rock, concrete, brick, stone and soil) forming most of the waste **(Table 3.1.3-B)**. The observed variations could be due, for example, to variations in the source of the waste, variations in the efficiency of segregation of materials, or mixing of C&D waste with other waste streams. Such variations could affect landfill operations and may reflect unfavourably at reclamation sites.

Material	Average Content (%)	Range (as % Composition)
Residuals	0.6	0-5
Vegetation	0.03	0-1
Carpet	0.5	0-10
Polystyrene insulation	0.3	02
Drums (55 gallons)	0.03	0-1
Air filters	0.01	0-1
Wall board	0.03	0-1
Glass	0.03	01
Aggregates	78.2	0-100
Metals	1.4	0-4
Cardboard	2.0	0-15
Paper	0.8	05
Wood	11.1	0-80
Plastic	1.3	0-3
MSW	3.6	0-85
Tires *	0.02	05
Furniture	0.2	0-3

Table 3.1.3B: Analysis of C&D Waste Reaching Al-Dhafra Landfill.

* Value does not include quantities disposed of directly in a special tire disposal area. Source: Globex-City Consult (2002; op cit. EAD, 2005h).

In 1998, C&D wastes generated in Al-Ain region were disposed of at a closed cement quarry and also at land reclamation sites around the city (ENTEC, 1998b). It was recommended to continue with this practice as long as safeguards are taken to ensure that only truly "inert" wastes are tipped at the quarry, which has the capacity to take such wastes for the next 40 years. Similar safeguards were recommended for C&D wastes used for land reclamation (ibid.).

Issues, Trends and Future Actions

C & D wastes seem to be well managed with few exceptions, and ongoing acceptable efforts and practices for recycling of material should be encouraged and facilitated.

Observed variation in the composition of C&D waste reaching landfills or reclamation sites suggests the need for more effective segregation, to insure complete removal of incompatible materials, whether hazardous or not. Recyclable materials must be recycled and reused. Only inert and suitable materials should be used for land reclamation purposes and landfill operations. Efficient recycling of some waste may require the introduction of certain equipment, *e.g.* to crush blocks of reinforced concrete to separate steel from cement blocks and recycle them separately. Some new legislation and arrangements are required to control and encourage various aspects of the process (Fichtner, 2005a).

Dumping of excavation materials to simple landfills is acceptable at present but need to be reduced significantly when these sites are upgraded to sanitary landfills (which will use only small quantities for construction and daily cover; Fichtner, 2005a). Municipalities will need to determine sites for landscaping and filling activities outside the sanitary landfills. It would be advisable to use crushing machines to separate residual reinforcement steel from building rubble, thus enhancing the potential for using the rubble in landscaping without any restrictions

Hazardous wastes resulting from construction (or demolition) sites should not be mixed with (or should be separated from) other inert materials, and should always be handled by companies permitted by EAD. These companies will have to provide the facilities and infrastructure required for the handling of these materials.

Projection of C&D waste quantities is quite difficult, being sensitive to changes in relevant government policy. The government has announced, for example, that 330 billion AED shall be invested in construction in the next 3 years, as compared to 130 billion in the last 3 years (Fichtner, 2005a). Based on available plans, Fichtner predicted a 150 - 200% increase in the quantity of construction and demolition wastes 5 years in the future (see **Table 3.1.3-C**). Different projections were expected for wastes from refurbishment of flats and military and police wastes.

Waste Source	Estimate from Available Data (ton/d)	Projection for Next 5 years (ton/d)
Excavation	Not estimated	
Road refurbishment	Not estimated	
Construction	400	1000-1200
Demolition Mineral Waste	370	900-1100
Demolition dumped interior finishings	20 - 40	50-100
Refurbishment of flats and houses	10 - 25	25-50
Military and Police	80	100-120
Total	**920-940**	**2100-2450**

Table 3.1.3C: Projection of C&D Waste Quantities from Greater Abu Dhabi

Source: Fichtner (2005a)

Recent records of Al-Dhafra landfill showed that quantities of C&D wastes reaching it have strongly increased in June 2005 (4900-7500 ton/d) compared to the end of 2004 (2500-2900 ton/d), probably due to a reduction in filling projects in the Emirate, and the diversion to the landfill of increased surplus of excavation material (Fichtner, 2005a).

3.1.4 Hazardous Waste from the Oil Sector

Definition

Hazardous wastes are defined in Section 2.4.

Hazardous wastes from the oil sector are mostly chemical in nature, together with some medical wastes from associated health care facilities, and radioactive wastes from well logging and certain other operations. Only non-medical and non-radioactive wastes shall be discussed in this section. Medical and radioactive wastes shall be discussed in sections 3.1.6 and 3.1.8, respectively.

Quantities

There are no statistics available with EAD at present on the rates of generation of hazardous wastes from the oil sector.

Management

The oil sector is the largest single industry in Abu Dhabi.

Wastes resulting from it are controlled by an ADNOC policy that establishes the guiding principles for waste management and disposal by ADNOC Group companies (ADNOC, 2003). This document outlines:

- Typical waste streams resulting from this sector (*e.g.* absorbents, contaminated soils, solvents, biocides, corrosion inhibitors, drilling fluids, spent catalysts, waste oils, sludges, etc.), many of which are potentially toxic and harmful to the environment.
- Waste classification scheme, with the hazardous wastes identified based on the Basel convention.
- Main sources of waste (*e.g.* seismic testing, drilling, construction, production, maintenance, site decommissioning, refineries, petrochemical industries).
- Strategy for waste management (through waste minimization, reuse, recycling, recovery, treatment and disposal), identifying potential methods for each approach.
- Guidelines for preparing waste management plans by Group Companies.
- Guidelines for the handling, storage and transport of waste, including the use of transport manifest and the contracting of permitted ESPs.
- Guidelines for international shipment of wastes.

In brief, ADNOC companies are expected to implement the waste management strategy and methods outlined in ADNOC (2003), in the hierarchy described therein. Each operating site (or group of sites) must provide a designated waste storage area to store wastes pending final disposal, and must keep an inventory of all stored wastes. Wastes must be segregated into hazardous and non-hazardous, and incompatible wastes must be segregated. Non-hazardous wastes are usually disposed of in designated municipal facilities (usually landfills) wherever available, whereas hazardous wastes are transported to a Central Environmental Protection Facility at Ruwais. Every hazardous waste transport step must be made under cover of a waste transfer consignment note.

At present, the Central Environmental Protection Facility at Ruwais is used only for interim storage of hazardous wastes, mostly drill cuttings, hydrocarbon and other sludges, catalysts and laboratory chemicals (see **Table 3.1.4-A**).

Additional waste handling units shall be added to the Central Environment Protection Facility by the end of 2006 and the beginning of 2007 (the BeAAT Project; **Table 3.1.4-B**). These units will be used to treat the wastes already stored at the facility as well as those generated anew by the 19 ADNOC companies. The project will also provide all infrastructure, general facilities, utilities, and management system required to support the process units and to monitor and register waste flows (ADNOC, 2005a). The facility is being exclusively built for the ADNOC group members and suppliers, based on projections of their rates of waste generation, and no hazardous waste from outside will be accepted (Fichtner, 2005a; p. p. 4-13).

On few occasions, shipments of hazardous wastes from ADNOC Group companies were exported for treatment / disposal in other countries following protocols of the Basel Convention with the approval of EAD and FEA.

No.	Name of Chemical	QTY (Ton)
1	Hydrocarbon Drill Cuttings	50,000
2	Hydrocarbon Sludge + Tar Sludge	3,500 +40
3	Hydrocarbon Sludge Contaminated With lead & Mercury	700
4	Treated Solids Of Drill Cuttings (Thermal Desorption)	40,000
5	Treated Solids Of Hydrocarbon Sludge (Centrifuge)	400
6	TEL Contaminated Sludge / Grit / Water	367
7	Pyrophoric Sludge / Iron Sludge	203
8	Effluent Treatment / Evaporation Pond Sludge	178
9	Coke Waste	85
10	Polymer Waste	56
11	Waste Oil	400
12	Sand Blast Grit / Garnet	660
13	Garnet Contaminated With Lead	280
14	Sulphur Waste	1344
15	Urea Waste	66
16	Asbestos	695
17	Insulation Foam Waste	40
18	Filter Waste Of Various Types	117
19	Rashing Rings	90
20	Polythene, Rubber, PVC Scraps	76
21	Paint Waste & Additives	100
22	Refractory & Asphaltene Material	65
23	Batteries	205
24	Fluorescent tubes / Bulbs	36
25	Waste Charcoal	660
26	Catalyst - Iron Oxide - SK - 201	123
27	Catalyst - Zinc Oxide	7
28	Catalyst - DHC - 8 / HC - 100 Lomax	250
29	Catalyst Mercury	16
30	Catalyst CR - 416	10
31	Catalyst HR 306	20
32	Catalyst & Ceramic Balls (Mixed)	345
33	Catalyst - Alumina	500
34	Molecular sieves	1390
35	Alumina Contaminated With Mercury	75
36	Bentonite (Drilling Chemical)	50
37	Refractory Material	24
38	Ion Exchange Resins	170
39	Valspar Corrocoat FBE Powder	160
40	Bitmac Coal Tar Wash Oil	138
41	Gardobon 4505 PC Chromate Solution	156
42	Barium Carbonate	100
43	Lignite Powder	22.5
44	Calcium Chloride	67
45	Lime	26
46	Calcium Carbonate	23
47	Fire Foam	36
48	Corrosion Inhibitor	117
49	Biocides	100
50	De - Emulsifier + Oil Dispersant	15 +29
51	Trichloroethylene	24
52	Glycol	163
53	Methanol	18
54	PH - Controller Emo - 634	36
55	Scale Inhibitor	46
56	Noxol (Effluent Cleaning Chemical)	135
57	Laboratory Chemicals (Solid)	830 KG
58	Laboratory Chemicals (Liquid)	1,022 Litres

Table 3.1.4A: Wastes Stored at Ruwais Interim Waste Facility

Source: ADNOC (2005b)

Unit / Process	Capacity	Waste groups
Landfill (class I)	310,000 ton (Total)	Grit, paint residues, solid chemicals
Landfill (class II)	115,000 ton (Total)	Mole sieves, asbestos, lagging, desiccants
Solidification	5,000 ton/year	Catalysts, supports, alkaline batteries, Urea
Thermal desorption	8,000 ton/year	Petroleum HC Sludge, clays, etc.
Centrifugation	5,000 ton/year	Raw Petroleum HC sludge
Incineration	5,500 ton/year	Various cleaning sludges, chemicals, filters
Physical Chemical Treatment	35 ton/year	Corrosion Inhibitors (inorganic)
Mercury	50 ton/year	Mercury containing tubes and bulbs

Table 3.1.4B: Waste Treatment and Disposal Units at ADNOC BeAAT Project

Source: ADNOC (2005a)

Issues, Trends and Future Actions

The BeAAT facility is likely to solve problems faced by ADNOC companies with the solid hazardous wastes that they generate. This should be verified by continued monitoring of the facility's performance.

3.1.5 Other Industrial Hazardous Waste

Definition

Hazardous wastes are defined in Section 2.4.

This section shall address non-radioactive hazardous wastes originating from industries outside the oil/gas sector. Radioactive wastes shall be discussed in section 3.1.8.

History

Until recently, solid waste generated in Abu Dhabi has been largely disposed of on dump sites, paying little attention to the segregation of hazardous wastes from municipal wastes. This is similar to the situation of many industrialized countries at the beginning of their solid waste management system development (Fichtner, 2005a; p.3-1). However, industrial hazardous wastes started to receive increasing attention in recent years, parallel to their increased rates of generation through diversification of the Emirate's industrial sector. This led to several management initiatives by the concerned parties, including proposals to establish new treatment and disposal facilities. It also led to more involvement by private sector companies in waste management.

Sources

Except for power and desalination plants, industrial activities that are not part of the oil sector are concentrated at present in three industrial areas at Mussafah, Mafraq and Al-Ain, and occur to a less extent in other areas (*e.g. e.g.* in Madinat Zayed, and south of Al-Ain City; **Table 3.1.5-A**). Part of Mussafah is designated and managed as the Industrial City of Abu Dhabi (ICAD), which is situated at the southern part of Mussafah and is planned to be extended towards the south in two phases. Preparations are already underway to establish Phase 1 Extension (about 10km2), whereas Phase 2 (about 60km2) will be established later on. An Industrial City at Al-Ain (AAIC) is also under planning.

Industrial areas		Area (Km2)
Existing	Mussafah	36
	Mafraq	7
	Al Ain	18
	Madinat Zayed	14
	Other areas with industry	7
	Total existing	**82**
Planned / in Progress	ICAD (presently in implementation)	16
	ICAD Phase 1 Extension	10
	ICAD Phase 2 Extension *	60 *
	Al Ain Industrial City (AAIC)	5
	Total planned / in progress	**91**

Table 3.1.5A: Industrial areas and their surfaces

* Addition to Fichtner's report.

Source: Fichtner (2005a).

Tables (3.1.5-B and C) identify the main industries and other activities occurring or planned within the industrial zones. At present, the Mussafah industrial area also includes a transfer station for municipal waste, a compost plant, and a medical waste treatment facility. The transfer station and compost plant are scheduled to be closed shortly (Section 3.1.1).

Type of Industry / Activity	Number	
	Existing	Newly Permitted
Water purification	10	8
Food and beverages	34	7
Textiles, fabrics, clothes and leather products	12	6
Wood and wood products	53	13
Fibreglass, plastic and rubber products	38	18
Paper and paper products	13	2
Chemicals	34	4
Building materials	56	4
Construction metal products	39	26
Other metal products	117	31
Ferrous and nonferrous metal fabrication	21	5
Fertilizers	4	1
Other Processing industries	110	131
Total	**541**	**256**

Table 3.1.5B: Existing and New Factories and Establishments in Mussafah (July 2005).

Source: EAD (2005g).

Activities occurring in industrial areas (e.g. **Figure 3.1.5-A**) may affect the environment directly through air emissions, noise, liquid discharges, solid hazardous and non-hazardous waste, and indirectly through consumption of water and power. Sites within industrial areas sometimes contained waste tires, metal drums, metal scrap, and building materials, as well as pits containing liquids, e.g. liquid bitumen and effluents from industrial processes or vehicle washing (EAD, 2003). Some sites with altered soil appearance were also frequently observed (Figures 3.1.5-B), suggesting contamination with oil or other materials. And some industries are known to generate hazardous

Industrial Area	Main Activities / Industries
Mafraq (existing) (1)	• Workshops and garages • Asphalt and bitumen processing • Ready mix concrete, bricks, pre-cast, and glass reinforced pipes Organic fertilizers • A medical waste treatment facility • Engineering firms • Assembly of electrical and mechanical equipment • Wastewater Treatment Plant
Al-Ain Industrial Zone (existing) (2)	• Workshops • Cement factory • Light industries
Al-Ain Industrial City (AAID) (proposed) (3)	• Warehouses • Small scale service and repair workshops Agricultural processing and food packaging Light manufacturing • Textiles, paper and wood products • Chemicals and plastics • Building materials • MDF Plant • Environmental industries • Technology cluster
ICAD Extension Phase 1 (proposed) (4)	• Warehouses • Automotive showrooms and services • Chemicals and plastics Construction materials Engineering and metals

Table 3.1.5C: Main Activities / Industries in Larger Industrial Areas

Sources:
(1) EAD (2003)
(2) EAD inspection and permitting records
(3) AAID Master Plan, from HCSEZ.
(4) ICAD Extension Master Plan, from HCSEZ.

wastes (e.g. sludge, paints, organic solvents, used oil). This section will address the role of industrial areas in generating solid and liquid waste. Impacts on the marine environment and on air quality are discussed in subsequent sections.-

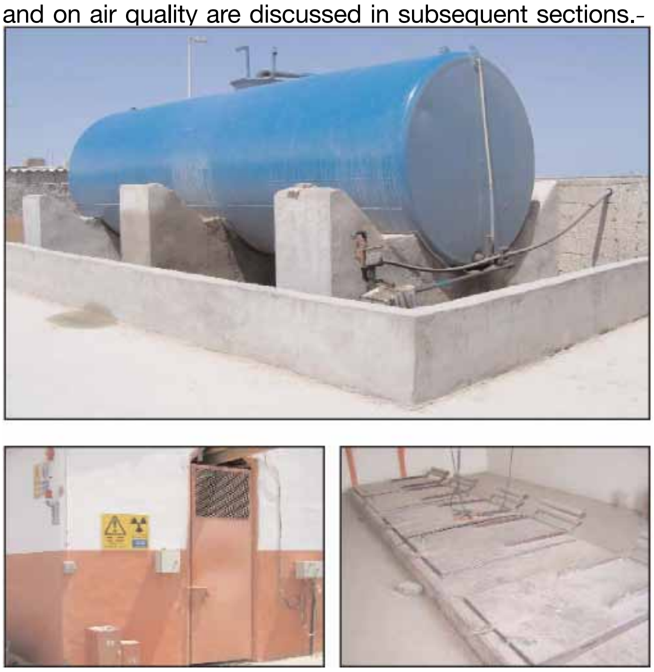


Figure 3.1.5A: Oil storage tank (top) and the interior and exterior of a radioactive sources storage facility in Mussafah. (EAD, 2005g).

Figure 3.1.5B: Contaminated soil. (EAD, 2005g)

Quantities

At present there are no quantitative data available with the authors on the solid wastes generated by power and desalination plants in Abu Dhabi Emirate. There are also no systematic records of quantities of hazardous wastes generated from other industrial sectors (Fichtner, 2005a). Data being collected by EAD are not yet sufficient to estimate quantities of wastes generated. Some estimates were made by consultants based on different approaches:

- ENTEC (1998b): Based on a survey of small, medium and large industries, they estimated industrial waste generation for Al-Ain at 122,000 ton/year, most of which was considered non-hazardous.
- Globex-City Consult (2000; op cit. Fichtner, 2005a): This study estimated that 132 tons/d of liquid hazardous wastes and 40 ton /d of solid hazardous wastes (48,000 and 15,000 ton/year, respectively) are generated from Greater Abu Dhabi Area. However, this study did not specify wastes by type, industrial sector or processes of origin, thus limiting its value for further assessment and projection of future waste generation (Fichtner, 2005a).
- Fichtner (2005a): By applying several approaches (including extrapolation from EAD data, waste generation rate per inhabitant, UNEP rapid assessment method per employee, waste generation rate per vehicle), the total quantity of hazardous wastes generated in Abu Dhabi Emirate in 2004 was estimated to fall between about 6000 and 12000 tons / year. This figure included 620-930 tons/d of household hazardous wastes, and 2000-2400 tons/d of used oil.

Management

Management of industrial hazardous wastes in Abu Dhabi Emirate is at its beginning. The biggest problem and challenge in this regard is the absence of adequate treatment and disposal facilities. A permitting system to control the disposal of hazardous wastes using existing facilities (mainly landfills) was started by Abu Dhabi Municipality in late 1990s, and is now implemented by EAD. However, shipments with hazardous content continue to reach landfills (most obviously at Al-Dhafra landfill) without being accompanied by a permit from EAD, for many reasons. Al-Dhafra landfill also continues to receive liquid wastes (including oily liquid wastes), in violation of principles of landfill operation, thus compounding problems with the landfill's environmental situation.

Until proper disposal facilities are established, options for the handling of hazardous wastes in Abu Dhabi at present are limited to the following:

- Storage by waste generators, by contracted environmental service providers, or at pre-designated sites within landfills.
- Recycling / reuse by private companies. This is most practiced for waste oil. Some companies collect aqueous oily wastes, separate the oil from water, and forward the resulting oil, together with any used oil, for re-processing, reportedly by factories in other

emirates. Other companies collect used oils and burn them as fuel, a practice that is being curtailed by EAD through its permitting and inspection operations.

- Collection and treatment by private companies. EAD started to enforce a system by which treatment and disposal of hazardous wastes can only be carried out through companies / methods that are licensed / approved by EAD.
- Disposal on landfills using interim methods proposed and agreed by EAD and the concerned municipality (*e.g.* solidification, encapsulation). According to this scheme, only methods accepted by the municipality concerned and approved by EAD shall be used. Requests for waste disposal shall be directed to the municipality concerned, which will coordinate and seek EAD approval before proceeding with waste disposal.

In all cases, a waste transport manifest should be used to document movement of the hazardous waste shipment, *e.g.* from the generator to the service provider and then to the final disposal site.

Issues, Trends and Future Actions

ENTEC (1998b) provided no projections for hazardous waste quantities generated in Al-in region, probably because hazardous wastes were considered much smaller than non-hazardous wastes.

A rough projection of hazardous waste quantities generated in Abu Dhabi emirate was made by considering and analyzing a set of waste quantity increasing factors (*e.g.* development of industry, industrial areas, population, and vehicles) and waste quantity decreasing factors (*e.g.* introduction of tariff systems) (Fichtner, 2005a). **Table (3.1.5-D)** shows projections of hazardous waste quantities that would be generated if no change in hazardous waste management would occur.

However, actual quantities of waste generated may be significantly smaller if waste management is improved, *e.g.* through enforcing more stringent legislation, provision of better facilities, or introduction of tariff systems. When considering such factors, it is estimated that quantities of hazardous wastes would more likely remain at the order of 6000 to 11000 ton/ year (Fichtner, 2005a).

Management of hazardous wastes is still at its beginning. A lot of work is needed by all parties concerned to improve the situation and solve the many problems facing this sector. The corner stone of any future direction in this regard is the establishment of adequate treatment and disposal facilities.

Al-Ain Municipality is about to commission a single-lined landfill that can be used for the disposal of some hazardous wastes and two incinerators that can be used for medical and some hazardous wastes.

The current practice of disposing hazardous wastes at Al-Dhafra landfill should be stopped as soon as possible. Abu Dhabi Municipality had plans to establish a lined landfill in addition to a station for physical and chemical treatment of hazardous wastes. These plans and the whole issue are being re-studied through a project that is being implemented by the solid waste privatization committee (Section 3.1.1). This project shall address many aspects of industrial hazardous wastes, including (Fichtner, 2005a):

- Development of a concept for the management of hazardous wastes, aiming first at their segregation from municipal wastes.
- Development of adequate treatment facilities, and of intermediate solutions (*e.g.* storage) until then. The interim methods proposed by EAD and municipality for implementation at Al-Dhafra landfill shall be reviewed.

Source	Estimate for 2004 (ton/year)	Projection* for 2010 (ton/year)	Projection* for 2015 (ton/year)
Industry	3000-8500	4140-11800	5700-16300
Households	620-930	740-1100	875-1300
Vehicle Workshops			
• Used oil • Other hazardous waste	2000-2400 200-500	2500-3000 250-600	3000-3600 300-720
Total	**5820-12330**	**7630-16500**	**9875-21920**

Table 3.1.5D: Hazardous Waste Projections for Abu Dhabi Emirate

Source: Fichtner (2005a)*
* Based only on waste quantity increasing factors – see text.

3.1.6 Medical Waste

Definition

UAE federal environmental byelaws define medical waste as "wastes made wholly or partly of animal or human tissue, blood or other fluids, excretion, drugs or other pharmaceutical products, swabs or dressing or syringes or needles or other sharp instruments, and any other infectious waste or chemical or radioactive waste arising from medical, nursing, dental, veterinary, pharmaceutical or other practices, investigation, research, teaching, or sample collection and storage".

Accordingly, medical wastes would encompass the following types, each requiring special ways for handling and disposal:

- Infectious wastes
- Chemical wastes
- Radioactive wastes
- Expired medicines and pharmaceuticals.

Radioactive wastes shall be discussed in Section 3.1.8.

History

Until few years ago, medical wastes in Abu Dhabi Emirate were disposed of by incinerators, most of which are relatively old (**Tables 3.1.6-A and 3.1.6-B**).

No.	Hospital	Year Incinerator Commissioned (Age in Years)
1	Oasis	1999
2	Tawam	1988
3	Al-Jimi	(12)
4	Al-Shwaib	(11)
5	Al-Faqe'	(11)
6	Al-Hayer	(11)
7	Al-Quaa	(11)
8	AlWagan	(11)
9	Meziad	1988
10	Al-Sad	(11)
11	Al-Khazna	(11)
12	Ramah	(11)

Table 3.1.6A: Medical Waste Incinerators in Al-Ain Region
Source: EAD (2004b)

No.	Hospital	Year Incinerator Commissioned	Capacity (Kg/h)	Date Shutdown
1	Mafraq	1983 1997	1400	1 February 2000
2	Al-Jazira & Central	1979 1985	200	2002
3	Corniche	1984	350	1 April 2002

Table 3.1.6B: Medical Waste Incinerators in Greater Abu Dhabi Area (all not in use at present

Source: EAD (2004b)

The environmental performance of medical waste incinerators in Abu Dhabi Emirate was evaluated and was considered inadequate for several reasons (ENTEC, 1998; Maunsell, 2004, pp. ii, 15; EAD, 2004b):

- Proximity to residential areas.
- Old equipment and technology.
- Insufficient waste segregation at source, thus increasing waste volumes reaching the incinerator and lowering its performance. The combustion of incompatible materials may cause harmful emissions.
- The operating temperature is below that required for complete incineration.
- Insufficient or lack of control of air emissions.
- No air monitoring system to confirm compliance with standards.
- Unacceptable operating standards / conditions (e.g. damaged linings, inadequate maintenance of air control filters) (see figure 3.1.6-A).

Figure 3.1.6A: Sub-Standard medical waste incinerator.

Excessive costs required for rehabilitating existing incinerators and bringing them to international standards prompted search for alternative methods. In late 1990's, Abu Dhabi Municipality started to close incinerators in Greater Abu Dhabi Area, replaced them with non-incineration methods provided by private contractors, and put plans to build a central incinerator for medical waste. Al-Ain Municipality also started to build a central incinerator to replace the existing ones. By December of 2003 all incinerators in Abu Dhabi were already shut down whereas those in Al-Ain were still running. In May 2004 a new stack was commissioned for the relatively new incinerator at Oasis Hospital, under the direction of EAD, as a temporary solution until the Municipality's central incinerator is completed. Later, the General Authority for Health Services closed most hospital incinerators in Al-Ain region, contracted private companies employing non-incineration methods on the interim period, and in 2005 initiated a tender to provide more efficient and modern disposal facilities.

There were also changes in the legal instruments controlling medical wastes management. Law (4 of 1998) was the first to specifically target this issue in Abu Dhabi Emirate. The law was incorporated into bylaws of the federal environmental law, as well as in a detailed code of practice prepared by the Ministry of Health to guide health officials of hospitals in implementing the law. This law was superseded by law (21 of 2005).

Quantities

Health care facilities of different types and sizes (Table 3.1.6-C) contribute to the total amount of medical wastes generated in Abu Dhabi Emirate. ENTEC (1998b) estimated medical waste generation from Al-Ain region at about 550 ton/year (1.5 ton /day), mostly from the larger Tawam and Al-Ain government hospitals (1.2 ton/day). A higher estimate for Al-Ain was given by Fichtner (2005b), who also estimated quantity for the medical waste generated in Greater Abu Dhabi and the Western Region (Table 3.1.6-D). In addition, EAD receives monthly reports from private companies collecting and treating infectious medical waste (Figure 3.1.6-B).

Type of Facility	Number			
	Government Sector		Private Sector	
	Abu Dhabi	Al-Ain	Abu Dhabi	Al-Ain
Hospitals	9	4	5	4
Clinics	22	21	298	100
Pharmacies	41	28	202	91
Laboratories	48	6	17	4

Table 3.1.6C: Sources of medical wastes in Abu Dhabi Emirate.

Source: Statistics Section, Ministry of Health (op cit., EAD, 2004b).

Region	Generated Medical Waste (ton/d)	
	Public sector	Private
Abu Dhabi and the Western Region	5.4	1.8
	2.6	0.4

Table 3.1.6D: Estimates of Medical Wastes Generated in Abu Dhabi Emirate

Source: Fichtner (2005b)

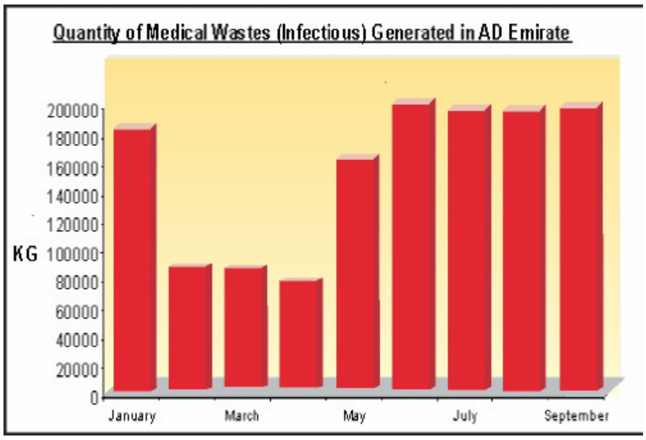


Figure 3.1.6B: Quantities of infectious wastes reported to EAD by private waste handlers in Abu Dhabi Emirate.

(Estimates for Feb-April do not include wastes of some larger hospitals).

A quantity of medical wastes produced by ADNOC Central Clinic in Abu Dhabi City and medical services in remote areas **(Table 3.1.6-E)** are also handled by private companies.

Source		Quantity
Abu Dhabi Central Clinic	Nursing and Medical	3 bags / day
	Pathology Laboratory	60 L/day biohazard waste 15 L/day biohazard sharps 20 L/day biohazard contaminated washing fluids
Remote areas medical services		1000 Kg / month

Table 3.1.6E: Medical Wastes Generated by ADNOC Health Care Facilities

Source: ADNOC (2005b)

Much smaller quantities of other types of medical wastes (cytotoxic, chemical) are also produced.

Management

Health care facilities are expected to manage their wastes in accordance with provisions of the relevant federal byelaw, but variations do occur in practice, either for lack of adequate treatment arrangements and facilities, or for lack of adequate internal waste management systems.

Cytotoxic and radioactive wastes are almost always segregated and handled separately. The remaining waste streams are not treated consistently in all health facilities. Segregation of infectious wastes from other non-medical waste streams is not practiced strongly enough in most facilities, thus increasing the overall amounts of infectious wastes generated. And chemical wastes are sometimes not sufficiently segregated from other waste streams.

Field visits in mid-2004 showed that some larger hospitals are equipped with air-conditioned, tiled facilities for storage of infectious wastes and other thermally labile waste streams (*e.g.* **Figure 3.1.6-C**), while other hospitals had inadequate storage facilities (*e.g.* 3.1.6-D) (EAD, 2004b; Fichtner, 2005a). At present, waste handling practices in hospitals are under stricter control by GAHS.

Figure 3.1.6C: Air conditioned and tiled storage room for medical wastes (EAD, 2004b).

Figure 3.1.6D: Inadequate storage of medical wastes.(EAD, 2004b)

Infectious Wastes

At present, Al-Ain Central Hospital (at Al-Jimi) is reportedly still incinerating its infectious wastes on site, although they plan to stop this practice and contract a private company in future (Fichtner, 2005a). No other incinerators are used for the disposal of infectious wastes, which are collected and handled by two private companies that use non-incineration technologies:

- Condor Company: Infectious wastes are disinfected by chemical treatment with chlorine dioxide, followed by drying and disposal of the resulting material to municipality landfill. It started operation in 1997. Its treatment unit has a capacity of 200-250 kg/h and works 8-10 hors /day, 6 days a week. The company overall is estimated to handle about 4 tons/day (Fichtner, 2005a).
- New Cleaning establishment: Infectious wastes are sterilized by a steam-based system, followed by drying and disposal of the resulting material to municipality landfill. It started work in 1999, the system has a capacity of 200 kg/hour, and the establishment overall is estimated to handle about 3 tons/day (Fichtner, 2005a).

These two companies handle wastes of most hospitals and clinics in Abu Dhabi Emirate, either through direct contracts or through sub-contracts with general cleaning companies. Inspection by EAD and GAHS showed deficiencies in their performance, mainly due to the nature of the technologies used and the large volumes of wastes they have to handle.

Cytotoxic Wastes

Cytotoxic waste is collected from concerned health care facilities by a private company (Condor) for incineration at Tawam Hospital. Based on available information, it is estimated that about 25-30 bags (75-90 kg) are incinerated per day (about 2.2-2.7 ton/month), an estimate that is considered high in view of other factors (Fichtner, 2005a). Also incinerated are about 2 tons/year of cytotoxic waste produced by hospital of Sheikh Khalifa Military City.

Expired Pharmaceuticals

Expired pharmaceuticals used to be disposed of at dump sites. Recently, some shipments of expired medicines and pharmaceuticals were disposed of in Al-Dhafra landfill by private sector service providers using a solidification technique.

Chemicals

Chemical wastes generated by health-care facilities are handled in a number of ways, including (EAD, 2004b; Fichtner, 2005a):

- Recycling through special equipment (*e.g.* xylene and formaldehyde at Sheikh Khalifa Hospital).
- Disposal in the sewer system (*e.g.* formaldehyde at Jazira Hospital; effluents of developing machines of x-ray films).
- Storage, if no disposal methods are available (*e.g.* xylene at Tawam hospital).

Recently, GAHS authorized the incineration at Tawam Hospital of at least some of the generated chemical wastes, as a temporary solution until more adequate disposal methods become available.

Radioactive Medical Wastes

Handling of radioactive medical wastes is discussed in Section 3.1.8.

Issues, Trends, and Future Actions

When the expected increase in Al-Ain population was assessed together with the expected future enhancement of waste segregation practices within hospitals, ENTEC (1998b) expected quantities of generated medical wastes to double by the year 2015. Corresponding projections for Greater Abu Dhabi and the Western Region are not available.

The management of health care wastes needs improvement in many resects.

Waste segregation is extremely inefficient, resulting particularly in very high generation rates of infectious wastes (*e.g.,* average 2.9 kg/bed/day for one of the hospitals; Fichtner, 2005a). These rates should be greatly reduced by improving waste segregation at source, especially segregation of infectious wastes from the much larger quantities of municipal solid wastes.

Certain wastes (*e.g.* chemical wastes) must always be separated from other waste streams and treated separately.

Waste storage facilities at some health care facilities need to be provided or improved.

There are inadequacies in the performance of available treatment and disposal facilities, including the two private companies collecting and treating infectious wastes. Because of these inadequacies, concerned authorities should seek better disposal facilities whether based on incineration or non-incineration technologies. Efforts and proposals to secure such facilities are already in progress:

- Al Ain Municipality is in the process of commissioning two incinerators, each having a capacity of 250 kg/h, at a site southwest of Al-Ain City.
- Plans by Abu Dhabi Municipality to establish a medical waste incinerator are now being reviewed by the waste management committee established by the Executive Council (Section 3.1.1).
- A recent tender announced by the General Authority for Health Services to provide facilities for medical waste disposal is also being re-evaluated by the above mentioned committee.

Equipment for recycling of hazardous chemicals should be provided whenever justified.

Systems for waste management at individual health care facilities need to be improved, *e.g.* through designating a staff member, a team or a unit with all tasks related to waste management.

More frequent inspection is needed to insure compliance of health-care facilities and service providers with environmental requirements.

3.1.7 Management of Chemicals and Hazardous Materials

Definition

UAE federal environmental law (24 of 1999) defines hazardous substances as “solid, liquid or gaseous substances having properties harmful to human health or adverse impacts on the environment such as toxic substances, explosives, flammable or ionizing radioactive substances”. The federal byelaw on the “Handling of Hazardous Materials, Hazardous Wastes and Medical Wastes” further identifies hazardous materials subject to its control and classifies them into 8 categories by reference to relevant U.N. recommendations, as follows (schedule 1.1, of Annex 1 of the byelaw):

1. Explosives.
2. Pressurized, liquefied, inflammable or poisonous gases.
3. Inflammable fluids.
4. Inflammable solid materials, self-igniting solid materials, and solid materials inflammable upon touching water.
5. Oxidizing materials and organic peroxides.
6. Poisonous materials and infectious materials.
7. Corrosive materials.
8. Other hazardous materials.

This schedule does not include Category 7 of UN Recommendations (*i.e.* Radioactive Materials) because they are handled differently at the international level (by IAEA) as well as at the national level (by federal law 1 of 2002). These materials are addressed in Section 3.1.8 of this sector paper.

Sources and Quantities

Chemicals and hazardous materials could either be imported into the country from outside sources, or manufactured locally. Statistics of imported chemicals can be generated through the management system described below (see **Table 3.1.7-A** for examples of target chemicals). Information on production capacities collected during the environmental permitting of factories can also provide estimates of the quantities produced locally.

Management

Following passage of the federal environmental law (in 1999) and its bylaws (in 2001), EAD started to implement a programme for the management of chemicals and hazardous materials in Abu Dhabi Emirate. The programme aims to provide society and the environment with the highest degree of protection against the hazards of these materials throughout their lifecycle, from manufacture or import to final disposal. To this end, EAD:

- Coordinated with concerned local and federal government bodies.
- Compiled lists of the target chemicals and hazardous materials (Table 3.1.7-A), some of which are controlled by other agencies, e.g. for being precursors of narcotics or chemical warfare agents.
- Developed forms and procedures to control the import, handling and transport of chemicals and hazardous materials.
- Prepared relevant codes of practice.

Management of chemicals and hazardous materials in general relies on four elements, namely:

- Permitting of handlers.
- Issue of import, export or re-export permits for restricted materials.
- Customs release operations and inspection at points of entry, to control and monitor the quantity and quality of imported materials.
- Inspection and control of materials throughout all stages of their handling.

EAD started in 2002 a system to permit all activities and establishments that may have environmental impacts, including those handling different types of hazardous materials, through coordination with Abu Dhabi and Al-Ain municipalities and the Department of Economy and Planning.

Section 2.3 and **Table (3.1.5-B)** provide numbers of environmental permits issued to different types of facilities to date.

In 2003, and through coordination with Abu Dhabi Customs, Seaports Authority, and other local agencies, EAD appointed staff at Abu Dhabi points of entry to check incoming shipments of chemicals and hazardous materials before their release, in coordination with other concerned agencies.

Subject materials arriving at the POE are classified into three categories based on their regulatory status:

- Banned (*i.e.* should be prevented from entering the country);
- Restricted (*i.e.* should not be allowed to enter unless accompanied by an import permits from a concerned agency); and
- Non-restricted (*i.e.* can be imported without restriction, but subject to compliance with applicable specifications).

Upon examination, a shipment of a banned material is penalized, bonded, or returned to source. A shipment of a restricted material is released if accompanied with a proper import permit from the federal agency restricting that material (*e.g.* MAF in case of a pesticide; MOH in case of a narcotics precursor). Otherwise, the shipment is bonded until a written approval is obtained from the proper agency. If approval is not granted, the shipment is treated as banned.

I. Banned Materials		
Group	**Concerned Authority ***	**Reference List / Reference**
Banned pesticides	MAF	• Annex 1, byelaw on the handling of pesticides, fertilizers and agrochemicals, of the federal environmental law (24/1999). • Lists annexed to MAF Decision No. (193/2004)
Banned Industrial Chemicals	MAF	• Lists annexed to MAF Decision No. (193/2004), which included Crocidolite, • Actionlite, Anthophyllite, Amo site, Tremolite, Polybrominated biphenyls, (PBBs), • Polychlorinated bihenyls (PCBs), Polychlorinated terphenyls (PCT) and Tris • (2,3-dibromopropyl phosphate.
Hazardous wastes	FEA	• Annex 1.2, byelaw on the handling of hazardous materials, hazardous wastes and medical wastes, of the federal environmental law (24/1999). • Annexes 1 and 8 of the Basel Convention.
II. Restricted Materials		
Group	**Concerned Authority ***	**Reference List / Reference**
Non-banned pesticides	MAF	• MAF lists of registered pesticides.
Precursors of chemical warfare	MOI / MOD	• Schedules 1-3 of the convention for the prohibition of chemical warfare
Precursors of narcotics	MOH / MOI	• List annexed to the 1988 convention on narcotics control.
Explosives, analogues and precursors	MOI	• Chemicals of hazard class 1, on the UN list of hazardous materials.
Ozonedepleting substances	FEA	• List annexed to FEA Board Decision No 13 of 1999. • Lists of UNEP's Ozone Action Programme
Other hazardous Materials	-	• Chemicals of hazard classes 2-6, 8, and 9, on the UN list of hazardous materials:
* FEA= Federal Environmental Agency; MAF = Ministry of Agriculture and Fisheries; MEW = Ministry of Electricity and Water (now Ministry of Energy); MOD = Ministry of Defense; MOI = Ministry of Interior; MOH = Ministry of Health.		

Table 3.1.7A: Groups of Non-Radioactive Materials Targeted by EAD's Chemicals and Hazardous Materials Management Programme

At present there is no unified UAE-wide mechanism for issuing import permits for chemicals of hazard classes 2-6, 8, and 9 on the UN list of hazardous materials. Until such a mechanism is implemented, these materials are being handled by EAD as non-restricted.

Abu Dhabi Chemicals and Hazardous Materials Management System

Recognizing the need for efficient management of chemicals and hazardous materials, EAD developed a web-based information management system (Abu Dhabi Chemicals and Hazardous Materials Management System, ADCHMMS, available at http//:adchmms@erwda.gov.ae). The system allows EAD staff to perform different functions, including:

- Perform permitting operations at EAD offices at Abu Dhabi and Al-Ain.
- Perform release operations at points of entry.
- Create and access records of importers and handlers.
- Create and store inspection reports.
- Create and store reports of complaints and emergency response operations.
- Search and print lists of banned and restricted materials.
- Search for and print MSDS of selected materials.
- Review and print relevant laws and regulations.
- Print application forms for environmental permits.

The latter four functions are also accessible by the general public.

Issues, Trends, Future Actions

Management of hazardous materials requires further attention in the following respects:

- EAD's present scope of work at POEs, which covers imported chemicals of all types, whether they are banned, restricted, or non-restricted.
- At present, import permits are issued by federal ministries / agencies for only few of the hazardous materials restricted by the federal environmental law and UN recommendations (*e.g.* for pesticides and precursors of narcotics, which are also restricted by other laws). The rest of the materials restricted by the federal environmental law are allowed to enter through most UAE points of entry without being accompanied with import permits.
- Controls on chemicals and hazardous materials imported through UAE's points of entry are different in the different emirates.

The latter two issues are being discussed by FEA and competent environmental authorities in individual emirates to design and implement a UAE-wide unified system that insures a balanced and consistent application of the federal environmental law.

Two ongoing initiatives are likely to introduce significant changes to ADCHMMS, namely:

- A web based software being implemented by Abu Dhabi Customs. Linking ADCHMMS with this software will enhance and streamline the release operations performed by EAD staff at customs POE.
- An e-Services initiative being implemented by EAD. This initiative is expected to bring EAD services and databases to a new level of efficiency and integration with each other, and with services and databases offered by other departments within Abu Dhabi Emirate.

3.1.8 Radioactive Sources and Waste

Definition

The term "radioactive sources" is used in this section to refer to sources of "ionizing radiation", which could come in different forms:

- **Open Sources:** Radioisotopes that are not permanently sealed in containers, so they may come in direct contact with objects or environmental matrices. They include, for example, isotopes used for medical diagnosis and therapeutic purposes in the form of liquids (*e.g.* isotopes of technetium and gallium), solids (*e.g.* isotopes of iodine), or gases (*e.g.* isotopes of xenon and Krypton).
- **Sealed Sources:** Radioisotopes that are permanently fixed within completely sealed capsules or within tightly sealed solid enclosures that can be opened only by special equipment.
- **Radiation Generators:** Equipment capable of generating ionizing radiation, *e.g.* x-ray, neutrons, or electrons, when operated.

These sources have wide applications, notably in medicine, industry, food sterilization and well logging operations. However, they should be treated with extreme care because of the many hazards associated with ionizing radiation (*e.g.* cancer, hereditary problems, and death).

History

Historically, radioactive sources were controlled in the UAE by the Civil Defense based on their general statutory authority to protect the population from risks and dangers posed by materials, premises, vehicles, or accidents involving them. The Civil Defense was registering handlers, inspecting them, and controlling import, re-export and the movement of radioactive sources throughout the UAE. However, law (1 of 2002) named the Ministry of

Electricity and water (MEW; now the Ministry of Energy) as the competent federal authority for the control of radiation sources. A decision by the Council of Ministers in 2005 named FEA as the competent federal authority in this regard.

Law (1 of 2002) stipulates that the federal authority (whether MEW or FEA) will have to coordinate with a local competent authority in each emirate. EAD has been in contact with both MEW and the Civil Defense since 2002 to coordinate on all aspects of concern, and will continue to coordinate with FEA.

Management of Radioactive Sources

Because of the transitional regulatory situation in the UAE (above), radioactive sources are being managed in Abu Dhabi Emirate at present in cooperation with both MEW/MOE and the Civil Defense, mainly through cooperating in the following (see **Tables 3.1.8-A, B**):

- Permitting and inspection of handlers of radioactive sources.
- Licensing of vehicles transporting radioactive sources (by the CD).
- Checking and verifying shipments of radioactive sources arriving at Abu Dhabi POE.
- Checking and verifying radioactive sources being shipped from companies in Abu Dhabi Emirate to other destinations.

Number of imported sealed sources,	204
Number of imported unsealed (i.e. open) sources	249
Number of re-exported sealed sources	75

Table 3.1.8A: Some Statistics related to Radioactive Sources Management in Abu Dhabi Emirate for 2005 (until November 2005)

Isotope	Numbers Imported		
	2003	2004	2005
Amercicium-241	2	7	9
Amercicium-241Be	3	10	1
Cesium-137	8	12	22
Cobalt-60	-	1	-
Galliium-67	18	18	4
Iodine-131	46	66	12
Iridium-192	48	45	15
Krypton-85	-	1	-
Radium-226	3	2	-
Selenium-75	3	1	3
Strontium-89	3	1	-
Technitium-99m	23	40	6
Tritium-3	2	4	11

Table 3.1.8B: Most Imported Isotopes in Abu Dhabi Emirate, Based on EAD Records until July 2005

Management of Radioactive Wastes

Radioactive wastes are substances containing radionuclides or radioactive materials whatever their physical form, and for which no further use is foreseen, and therefore will be confined in order to control their emission to the environment.

Federal laws (24 of 1999) and (1 of 2002) prohibit the disposal of any imported radioactive waste in the UAE. Radioactive wastes generated locally may be managed in different ways, depending on the isotope involved and its form, activity and half-life.

Health care facilities in Abu Dhabi Emirate may generate radioactive wastes of different types, which may need to be handled differently (EAD, 2004b):

- A number of unused radioactive sources (*e.g.* Cs-137, Co-60, C0-57) have been collected and stored at a special facility at Tawam Hospital. Such sources are no longer imported (being replaced with shorter half-life alternatives), and there are plans by hospital management to re-export the existing stock.
- Medium activity sources, imported mainly for calibration purposes, are kept at special stores at the health care facilities. A central repository for these sources is recommended, so that health facilities can use sources already present in the Emirate instead of importing new ones.
- Short half-life radiation sources are returned to

source, or stored until their activity drops to safe levels then disposed of as municipal waste.

- Short half-life radiation wastes generated from chemotherapy at Tawam Hospital are incinerated after their activity drops to safe levels. The hospital also receives and incinerates similar waste generated from other hospitals.

Sealed sources used in industry have to be stored in specially equipped stores (*e.g.* **Figure 3.1.5-A**). Once exhausted, some sources are re-exported to the manufacturer for recharge (*e.g.* in case of Ir-192 sources). Sources that are not exhausted and no longer required must be returned to source countries for disposal.

EAD and the concerned federal authorities must be informed when a radioactive source is lost for any reason. If a sealed source becomes stuck in a well at a location and depth from which it cannot be recovered, the following actions are required:

- Owner of the source must have emergency plans pre-approved by EAD and the federal competent authority.
- Owner of the source must notify EAD and the federal competent authority as soon as possible of the incident, its circumstances and ongoing and planned efforts to deal with it.
- Owner of the source, in cooperation with the owner of the well, must try everything possible to fish the source, and should not abandon it unless permitted to do so by EAD and the federal competent authority.
- There should be continuous monitoring at the surface for possible presence of radioactive contamination.
- Owner of the source must submit a detailed report of the incident and abandonment procedures.

Well drilling operations may produce materials contaminated with naturally occurring radioisotopes (the so-called, naturally occurring radioactive materials, NORMs). Plans for enhancing the management and disposal of such materials are under consideration.

Issues, Trends and Future Actions

There following key issues require attention and future action:

1. The system governing the handling of radioactive sources needs to be strengthened and the roles of relevant authorities need to be clarified, especially with regard to the issue of import and re-export permits.
2. Facilities are required for the safe storage of some radioactive sources and wastes, until permanent arrangement for their disposal are secured.

3.1.9 Pesticides

Definition

A pesticide is a chemical substance (or mixture of chemical substances) intended for preventing, destroying, repelling, or mitigating a particular target pest. The latter is a living organism that harms humans or their material, plant or animal belongings. This includes unwanted species of insects, rodents, worms, molluscs, algae, weeds, fungi, microorganisms and others.

Chemical pesticides may be classified according to their target pest (as insecticides, rodenticides, herbicides, fungicides, *etc.*) or by chemical composition (as organochlorine, organophosphorus, carbamate, pyrethroid, *etc.*).

History

Following the Second World War, chemical pesticides became widely used in agriculture and for public health purposes because they seemed to offer many advantages for pest control:

- Quick action.
- Relatively low cost compared to other pest control methods.
- Easy to use.

Use of pesticides has undoubtedly led to a very large increase in agricultural production and to a large improvement in public health. However, research started to show a number of health and environmental effects caused by pesticides **(Table 3.1.9-A).**

- High toxicity through inhalation, swallowing or dermal routes, leading to skin, nasal or eye irritation, diarrheadiarrhoea, vomiting, nausea, muscle cramps, even death.
- Long persistence in the environment.
- Long-range transport though the air, in vapour phase or adsorbed to suspended particles.
- Conversion to more stable metabolites.
- Ability to dissolve and accumulate in human or animal body fat to relatively high levels.
- Killing non-target beneficial organisms (*e.g.* bees) in addition to killing the target harmful pests (*e.g.* mosquito).
- Impacts on non-target organisms (*e.g.* egg shell thinning in some birds of prey and their near extinction due to accumulation to residues of DDT).
- Groundwater contamination due to improper storage or excessive use of pesticide.
- Carcinogenic and / or teratogenic effects.

Note: Table shows main impacts known to be caused by pesticides as a group, not by each individual pesticide.

Table 3.1.9A: Environmental and Health Impacts of Pesticides.

In general, two kinds of pesticide poisoning could be distinguished:

- Acute toxicity: This effect occurs soon after exposure and is manifested usually by death or occurrence of vomiting, nausea, dilation of pupils, convulsions, chills, nervousness, or headaches.
- Chronic Toxicity: This effect is due to repeated exposures over a long period of time and is manifested by the occurrence of cancer, mutations, or teratogenicity (i.e. birth defects in offspring).

Whether a pesticide would cause certain negative health effects depends on several factors, notably:

- Chemical and physical characteristics of the active ingredient.
- Route of entry of the pesticide into the human body (oral, dermal, or inhalation).
- Dosage or concentration of the pesticide.
- Duration of exposure.

Because of these potential effects, the use of pesticides is strictly controlled throughout the world, usually by a local competent authority in each country working in cooperation with specialized international organizations, mainly United Nations' Food and Agriculture Organization (FAO), World Health Organization (WHO), and their joint committees and programmes. The latter are responsible for setting permissible levels of pesticides in different matrices (the so-called Maximum Residue Levels, MRLs, *e.g.* in vegetables, groundwater, meat products, etc.) and for banning the use of certain high-risk pesticides.

The Ministry of Agriculture and Fisheries (MAF) is the federal authority charged by federal laws with the control of pesticides throughout the UAE, assisted by local authorities in the different Emirates.

Until very recently, pesticides were controlled in Abu Dhabi Emirate mostly by Al-Ain and Abu Dhabi municipalities, who are also main users of pesticides. However, law (16 of 2005) regarding the re-organization of EAD gave the agency more powers on the control of pesticides in the Emirate, and cancelled a previous law (No. 2 of 1999) related to the management of fertilizers and pesticides.

Management

Based on recent regulatory developments, pesticides in Abu Dhabi Emirate are to be managed by EAD in cooperation with other concerned bodies on the local level and with MAF on the federal level. Key elements of the management system include the following:

- The manufacture and formulation of pesticides are both prohibited in the UAE.
- Pesticides listed in **Table (3.1.9-B)** are banned entry into the UAE.
- Only pesticides registered by MAF can be imported into and used in the UAE.
- Importers and traders of pesticides must be per- mitted by MAF, EAD and the relevant municipali-

ty, and are subject to inspection by these three authorities.

- Pesticides cannot be imported without import permits from MAF.
- At customs points of entry, shipments of pesticides are released after inspection by MAF and concurrence by EAD.

Pesticides Used in Abu Dhabi

The past three decades have witnessed a large increase in the green areas in Abu Dhabi Emirate, through agriculture, forestry and gardening. This would not have been possible without the use of pesticides (this section) and fertilizers **(Section 3.2.7)**.

Table (3.1.9-C) shows types of pesticide formulations registered by MAF for use in the UAE, and by Abu Dhabi Municipality through a parallel registration scheme for use in Abu Dhabi Emirate.

Pesticides are imported by private companies in response to tenders announced by Abu Dhabi and Al-Ain Municipalities or for sale to other users. Both municipalities were asked in April of 2005 to provide an inventory of the pesticides they purchased and used in the past three years. The total amounts purchased by both municipalities over the past three years (roughly about 340 tons; **Table 3.1.9-D**) compare favourably with the total imports through the Emirate's POE. Based on EAD's release statistics, quantities of pesticides imported through Abu Dhabi customs points of entry in 2003 and 2004 were about 710 and 470 tons, respectively.

Table 3.1.9B: Pesticides Banned in the UAE

No.	Name	No.	Name
1	2,4,5-T (2,4,5- trichloro--phenoxy acetic acid)	18	Chloropicrin
2	Aldicarb	19	Chlorothalonil
3	Aldrin	20	Cyanazine
4	Aluminium phosphide	21	Cyhexatin
5	Amitrole, aminotripole	22	DDT(dichlorodiphenyl trichloroethane)
6	Arsenic Compounds	23	Demeton-S and -O
7	Atrazine	24	Demeton-S-methyl
8	Benomyl	25	Demeton-S
9	BHC (Benzene hexachloride)	26	Demeton-O
10	Camphochlor	27	(DBCP)
11	Captafol		
12	Captafol	28	Dichlorvos (DDVP)
13	Carbofuran	29	Dicofol
14	Chlordane	30	Dieldrin
15	Chlordecone	31	Dinoseb
16	Chlordimeform	32	Dinoseb Salts
17	Chlorobenzilate	33	Dinoseb Acetate

HCH (1,2,3,4,5,6-

No.	Name	No.	Name
34	Disulfoton	51	Methamidophos
35	EDB (Ethylene Dibromide)	52	Methomyl
36	Endosulfan	53	Methoxychlor
37	Endrin	54	Methyl bromide
38	Ethylpyrophosphate (TEPP)	55	Mevinphos
39	Flucythrinate	56	Mirex
40	Fluoroacetamide	57	Monocrotophos
41	Gamma HCH	58	Monocrotophos
42	Hexachlorocyclohexane)	59	Nitrofen
		60	Oxamyl
43	Heptachlor	61	Oxydemeton-methyl
44	Hexachlorobenzene (HCB)	62	Oxydeprofos
45	Kelevan	63	Paraquat
46	Leptophos	64	Parathion
47	Lindane	65	Parathion – methyl
48	Mancozeb	66	Pentachlorophenol (PCP)
49	Maneb	67	Phenylmercuric acetate
50	Mercury Compounds	68	Phenyl Mercury Acetate

Table 3.1.9B Continued: Pesticides Banned in the UAE

No.	Name	No.	Name
69	Phosphamidon	82	Ziram
70	Schradan	83	Binapacryl
71	Simazine	84	Carbaryl
72	Sodium Fluoride	85	Dichlorvos
73	Sodium Fluoroacetate	86	Dimefox
74	Strobane	87	Ethylene dichloride
75	Strychnine	88	Ethylene oxide
76	Telodrin	89	2-Ethyl-1 ,3-hexanediol
77	Thallium Sulphate	90	Fenthion
78	Thallium Sulphate	91	Heptenophos
79	Thiram	92	Tetrachlorvinphos
80	Zinc Phosphide	93	Vinclozolin
81	Zineb		

Table 3.1.9B Continued: Pesticides Banned in the UAE

Sources:

(1) Federal Environmental Byelaw on Pesticides, Agrochemicals and Fertilizers (2001).

(2) MAF Decision No. (193 / 2004) (Numbers 83 - 93).

No.	Classification	No. of Registered Formulations	
		MAF (2001)	Abu Dhabi Municipality (ADM, 2004)
1	Insecticides	83	85
2	Soil Insecticides/ Nematocides	13	10
3	Acaricides	4	12
4	Fungicides	61	63
5	Natural and Bio-Pesticides	24	33
6	Insect Growth Regulators	9	9
7	Herbicides (Restricted)	18	19
8	Chemosterilizers (Restricted)	6	6
9	Pheromones	14	23
10	Deodorizers	5	5
11	Adjuvants	6	8
12	Restricted use pesticides	34	60
13	Miscellaneous	6	7
14	Public health (General)	87	137
15	Public Health (Restricted)	31	36
16	Public Health (Miscellaneous)	5	4
Total		**406**	**517**

Table 3.1.9C: Pesticides Registered by MAF and Abu Dhabi Municipality

* Some pesticides in other forms (e.g. tubes, boxes, dunks) are excluded.

Municipality	Form of Pesticide *	Units	Quantity
Abu Dhabi **	Liquid	Litre	134,959
	Powder	Kg	44,159
Al-Ain ***	Liquid + Powder	Kg ****	164,650
Total		**Kg ******	**343,768**

Table 3.1.9D: Pesticides Purchased by Abu Dhabi and Al-Ain Municipalities over the years 2002-2004

** Total for Public Health Section and Protection and Laboratory Section.

*** Units were not given.

**** Numerical summation of the numbers given (1 unit = 1 kg = 1 litre).

Source: ADM (2005); AAM (2005a).

Residues in Vegetables and Fruits

Two recent studies assessed levels of pesticides in locally grown vegetables and fruits (**Table 3.1.9-E**).

Of 185 samples collected between 1998 and 2001, 79 samples showed residues of target pesticides, with the observed levels exceeding corresponding MRLs in only 8 samples (Albehaisi *et al.,* 2003).

Between December 2004 and April 2005, EAD (2005a) collected 26 samples of vegetables from different farms (Fig. 3.1.9-A). Samples were analyzed for two fungicides (Fenarimol, Dichlofluanid), one acaricide (Dinobuton), one insecticides-acaricide (Chlorpyrifos), and 11 insecticides (B endiocarb, Bromopropylate, Diazinon, Dimethoate, Deltamethrin, Phosmet, Primicarb, Profenofos, Tetradifon, Quinalphos, and Alpha-Cypermethrin). Residues of six target pesticides were detected in 9 of the samples, with three samples showing residues of two pesticides each. Of the six detected pesticides, only Pririmicarb occurred at concentrations exceeding the MRL in 3 samples of sweet corn, whereas MRLs of the other five (Chlorpyriphos, Quinalphos, Dinobuton, Profenofos, Fenarimol) were not available for the vegetables analyzed.

These results indicate that local vegetables may contain residues of some pesticides. However, more samples and pesticides will have to be analyzed over a longer period of time for a full assessment of the risks posed by such residues to the health of the consumers (EAD, 2005c).

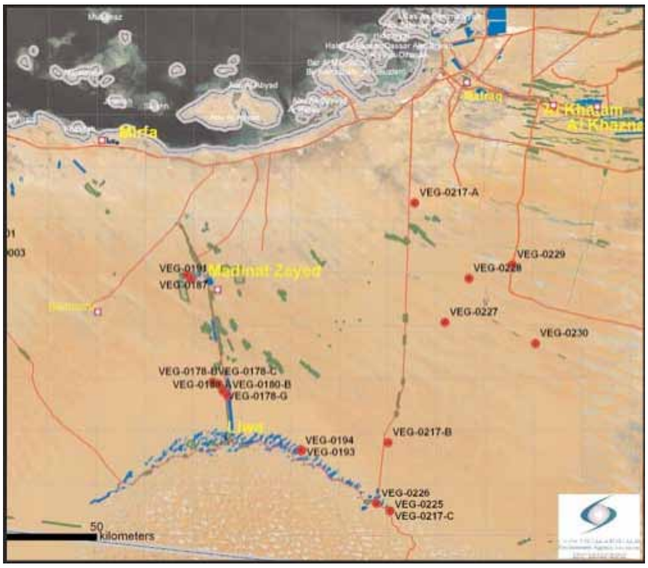


Figure 3.1.9A: Vegetables sampling sites (EAD, 2005a).

Year	Matrix	No. of Samples		Detected Pesticides	Range (mg/kg)	No. of Samples Above MRL
		Analyzed	Positive			
1998	Vegetables	31	10	Chlorpyriphos	0.03-0.34	1
				Triazophos	0.14-1.36	6
	Fruits	3	0	-		-
1999	Vegetables	51	20	Chlorpyriphs	0.01-0.48	-
				Endosulfan I	0,002, 0.0166	
				Fenitrothion	0.57	
				Traizophos	0.037-0.07	
				Bromopropylate	0.0104-0.0163	
				Endosulfan II	0.0137	
				Endosulfan sulphate	0.0336-0.0555	
				Irpodione	0.6094	
				Diazinon	0.009	
				Tolocophos-Methyl	0.06	
				Fenarimol	0.14	
				Chlorphenphos	0.06	
				Malathion	0.07, 0.19	
				Dimethoate	0.02	
	Fruits	14	10	Bromopropylate	0.0034-3.54	-
2000	Vegetables	39	20	Chlorpyriphs	0.003-1.537	1
				Endosulfan I	0.005-0.887	
				Endosulfan II	0.0658	
				Irpodione	0.0515	
				Pyrimiphos-Methyl	0.0026-0.0564	
				Tolocphos-Methyl	0.0043-0.006	
				Procymidone	0.03-0.79	
				Tecnazine	0.0272-0.0826	
				Bromopropylate	0.202	
				Parathion-ethyl	0.0376-0.8273	
	Fruits	5	1	Bromopropylate	0.003	-
2001	Vegetables	34	11	Fuzalone	0.01 5-0.0724	-
				Chlorpyriphs	0.0244-0.3446	
				Procymidone	0.6875	
				Malathion	0.1309	
	Fruits	18	7	Bromopropylate	0.0656-1.217	-
				Chlorpyriphs	0.003	
				Endosulfan sulphate	0.064	
				Pirimicarb	0.3899	
				Parathion-ethyl	0.0328	
				Fuzalone	0.01 62	
2004 -2005	Vegetables	26	9	Chlorpyriphs	0.03	3
				Dinobuton	0.02, 0.04	
				Fenarimol	0.08, 0.09	
				Pirimicarb	0.05-0.1	
				Profenofos	0.06	
				Quinalphos	0.0.7	

Table 3.1.9 E: Levels of Pesticides in Locally Grown Vegetables and Fruits

Sources: EAD (2005a) for 2004-2005 data; Albehaisi *et al.* (2003) for the rest.

Obsolete Pesticide Stocks

Obsolete pesticide stocks (i.e. pesticides that can no longer be used because of expiry or loss of biological activity, due to changes in physical characteristics or degradation of the active ingredients) may pose several health and environmental hazards.

Pesticide inventories received from Abu Dhabi and Al-Ain municipalities indicted that the first had no stocks of obsolete pesticides (ADM, 2005), whereas the latter had about 1900 kg and 2170 litres stored at one location (at Al-Foaa; AAM, 2005b). Pesticide formulations present in quantities exceeding 100 kg or 100 litre included the active ingredients Mancozeb, Tolclofos, Tetradifon, Bubrofezin, Difenzoquat Methyl Sulphate, Carbofuran, Teramiphos, Fenoxaprop Ethyl and triazophos. Some have expired years ago. A separate inventory received from AAM (2005a) indicated that some pesticides purchased over the years 2002-2004 were not used. However, the expiry status of these materials was not provided.

Additional quantities of obsolete pesticide stocks may be held by importers and retailers of pesticides, but there are no estimates of these at the present.

Currently Abu Dhabi Emirate has no facilities suitable for the disposal of obsolete pesticide stocks. Therefore, these wastes must either be returned to source or stored until suitable disposal methods become available. In the meantime, every effort must be made to minimize the amount of waste generated, e.g. by importing pesticides on as-need basis, with purchase conditions allowing unused stocks to be re-exported to countries of origin.

Issues, Trends and Future Actions

Relatively large quantities of pesticides were imported and used over the past four decades to satisfy needs of a growing agriculture sector that relied on increased utilization of groundwater and was associated with wastage of surplus vegetable products. Any changes in policies affecting the agriculture sector are likely to affect future demand for pesticides in the Emirate and patterns of their use.

EAD is expected to play a greater role in the management of pesticides in Abu Dhabi Emirate in fulfilment of law (16 of 2005), potentially through the following (EAD, 2005c):

1. Establish a pesticides management unit within EAD.

2. Coordinate with other concerned local and federal parties, especially with MAF on pesticides registration,and with MAF and other concerned parties to continue to provide extension and pest control services for agricultural and public health purposes.

3. Continue to permit handlers and inspect their premises and transport vehicles.

4. Complete an inventory of waste pesticides in the Emirate to insure their proper management.

Problems with obsolete pesticide stocks are expected to diminish in future when incinerators and other waste disposal facilities proposed by Al-Ain and Abu Dhabi municipalities are constructed and operational.

Further studies are required to fully assess the occurrence of pesticide residues in locally grown vegetables and fruits, their trends over time, and their impacts on public health.

3.1.10 Household Hazardous Wastes

Households produce limited amounts of hazardous wastes (*e.g.* batteries, paints, solvents, expired medicines) that are collectively known as "household hazardous wastes (HHW)".

At present, there are limited programmes for waste segregation and recycling in Abu Dhabi Emirate, so most of the HHW produced gets disposed of along with municipal solid wastes (MSW) and ends up in landfills. Fichtner (2005a) estimated that MSW produced from households and small businesses in Abu Dhabi Emirate in 2004 contained about 0.3% of hazardous constituents. Accordingly, hazardous waste quantities expected in MSW were estimated at about 3100 ton/year, of which 20-30% (620-930 tons/year) could be collected for separate processing. Assuming that Abu Dhabi population increases at about 3.5% per year, the amount of HHW that could be collected separately would increase to 740-1100 ton/year in 2010 and to 875-1300 ton/year in 2015 (ibid.).

The only way forward towards better management and safer disposal of HHW is to implement systems for waste segregation at source. However, such system would not succeed unless facilities for hazardous waste disposal are provided (Section 3.1.5), and there is strong awareness and participation by the general public.

3.1.11 Wastes from Marine Operations

If not adequately managed, marine operations (fishing, transportation, shipping, tourism, leisure activities, etc.) may litter the marine environment with a variety of solid wastes (lost fishing nets, food wastes and municipal garbage thrown overboard, etc.), some of which may be hazardous. At present there are no available data with the authors on the occurrence and quantities of such wastes in Abu Dhabi marine environment.

Littering and disposal of hazardous wastes into the marine environment are strictly prohibited by UAE federal environmental law and byelaws, which prescribe penalties for violators. These byelaws and international treaties also require port authorities to provide facilities for collecting, handling and disposal of ship generated waste (also see section 3.2.4 on ship ballast discharges).

A recent guideline issued by EAD (2005j) calls marina owners/operators to establish facilities to collect various wastes generated by smaller boats. This includes pump-out facilities for sewage, containers for separate collection of hazardous and non-hazardous solid wastes, and on-shore showers and lavatories. Boat operators are required to retain all generated solid waste for disposal using facilities at the marinas. Sewage from boats having on-board lavatories must also be disposed of using onshore pump-out facilities.

3.2 Liquid Discharges

3.2.1 Sewage (Domestic Effluents)

Definition

Sewage is a material that is mostly produced from human residences (see definitions in Table 3.2.1-A), and hence is sometimes referred to as "domestic wastewater". In reality, sewage may contain contributions from commercial and industrial sources, which are often discharged into sewers after meeting certain discharge standards. In general, sewage contains substances that are harmful to the public health, to animal or aquatic life or to the use of water for domestic water supply or for recreation.

The used water and water-carried solids from homes that flow in sewers to a wastewater treatment plant: http://www.alken-murray.com/glossarybug2.html
Refuse liquids or waste matter carried off by sewers: http://www.unesco.org/education/tlsf/TLSF/intro/glossary_links/glossary.htm
http://www.worldbank.org/depweb/english/modules/glossary.html
The used water and added waste of a community which is carried away by drains and sewers: http://www.sandiego.gov/mwwd/general/glossary.shtml
Human-generated wastewater that flows from homes, businesses, and industries: http://sfep.abag.ca.gov/pollutionprevention.html
The water-borne wastes of a house or community: http://www.johnstonsmith.co.uk/fact13.html

Table 3.2.1A: Selected Definitions of Sewage (updated 2008)

Note: Links updated 2008

History

Historically, the small population of Abu Dhabi Emirate resided mostly in Al-Ain and other oases in the Western Region (*e.g.* Liwa), where natural water supplies are more abundant, whereas Abu Dhabi Island and the coastline were sparsely populated. This situation started to change by early 1960's, with the large population growth and urbanization brought about by revenues of the oil sector. And the problem with sewage disposal became more apparent.

In the past four decades, Abu Dhabi Municipality (ADM) was key player in the management of sewage throughout the emirate except for the Eastern Region (managed by Al-Ain Municipality) and concession areas of oil companies (managed by ADNOC Group companies). Recently, the private sector became more involved in sewage management.

Since settlement of Abu Dhabi Island began in 1792, its population remained very small until 1958, the year oil was discovered in the Emirate. Ten years later, its population exceeded 20 thousand inhabitants then reached about 90 thousand in 1975. "Unfortunately, two thirds of the inhabitants were served by unsatisfactory septic tanks, emptied by the Department of Public Health. Being only few meters above sea level, septic tanks with soakways were always problematical, particularly in winter, due to the high groundwater level. The ever increasing population at the time compounded the problem. With sewage flooding becoming more common, and the associated public health risks, a piped sewerage system was the only option" (SPC, 1999, p. 16, 22).

The first sewerage system commissioned in 1973 included sewers with shallow gradients and a conventional activated-sludge treatment plant located on Abu Dhabi Island. A distribution centre next to the plant stored and pumped the treated effluent for use in irrigation. However, the plant could serve only 30,000 inhabitants and was almost immediately overloaded. There were also problems with the sewer lines (SPC, 1999; p. 21-23, 45).

These problems led in 1975 to the formulation of a sewage management master plan and creation of a Sewerage Projects Committee (SPC) chaired by Abu Dhabi Municipality. The committee opted to treat the sewage and to use the resulting treated water for irrigation, a policy that is still being implemented today throughout Abu Dhabi Emirate. Major elements of the 1975 master plan were completed by 1982, including a sewerage system, a treatment plant at Mafraq, and a system to return treated effluent to Abu Dhabi Island for use in irrigation. The old treatment plant on the island was decommissioned shortly afterwards (SPC, 1999, p. 21-23).

The combined sewerage and irrigation system grew overtime to cope with population growth and to serve new urban centres to the east and southeast of Abu Dhabi Island (Mussafah, Bani Yas, Al Wathba, the new international airport, Khalifa Cities and Al Raha, to the northeast towards Dubai (Shahama, Rahba, Bahia, Samha), and the smaller population centres in the Western Region (*e.g.* Liwa, Madinat Zayed, Ghayathi, Bida Al Mutawah, Delma Island) (SPC, 1999).

Mafraq sewage treatment plant (STP), the largest in Abu Dhabi, was established on two phases. The second phase was planned to be as large as the first, but unexpected large population growth necessitated a larger extension. Commissioning of phase 2 in 1997 brought plant's total treatment capacity to 260,625 m3/day, equivalent to 900,000 inhabitants (SPC, 199, p. p. 28-31). Mafraq STP now serves all the population in and around Abu Dhabi Island, whereas population centres in the Western Region are served by individual small STPs.

Severe flooding in Abu Dhabi Island due to exceptional rainfall in 1982 prompted a new policy and master plan for stormwater drainage, based on the construction of a separate network (SPC, 1999; p. p. 25-26). The same approach was adopted later on for other low-lying areas on the mainland.

The high cost of sewerage projects (*e.g.* 7 billion AED between 1975 and 1999; SPC, 1999; p. 33) prompted Abu Dhabi Municipality to start a programme to outsource the operation and maintenance of its sewerage facilities while retaining ownership and overall control of the assets. The programme started with newer facilities in the Western Region. The sewerage and surface water infrastructure on Abu Dhabi Island and the adjacent mainland was debundled into five contracts to be implemented by the end of 2001 (SPC, 1999; p. 100). In 2005, the Executive Council appointed Abu Dhabi Water and Electricity Authority (ADWEA) to take over all sewerage facilities as a further step towards their privatization. Abu Dhabi Sewerage Company was subsequently created.

Similar schemes are adopted by Al-Ain Municipality for the Eastern Region, whereby sewage is collected, treated then used for irrigation (Maunsell, 2004; p. 13). The area is served by a main STP located at Zakher, about 25 km to the south of the city centre, as well as by 14 regional STPs serving peripheral communities. Small populations in the outlying villages are not connected to the municipal sewer and are served by septic tanks that are emptied by the municipality on regular basis. However, there are plans to connect more of these populations to STPs (*e.g.* at Abu Samrah), as well as to implement a Drainage Master Plan for Al-Ain (Maunsell, 2004, p. 10, 15-16).

Most of the sewage generated by ADNOC Group companies onshore, offshore and on Islands is handled by relatively small STPs. Small quantities from sources not connected to treatment facilities (*e.g.* at Borouge complex) are collected in storage pits from where the sewage is collected by tankers for treatment / disposal in some STPs. On one location (CFP L/Q), about 20 m3/d of sewage are reportedly discharged to the sea after maceration and disinfection by chlorination. On two other locations, about 20-30 m3/d of raw sewage are reportedly discharged to the sea without treatment, pending the installation of a new treatment facility (Zakum) or the replacement of a faulty one (Umm Shaif). Target completion date for both installations is quarter 4/2005. (ADNOC, 2005b).

As a result of all the above mentioned developments, almost all urban areas of Abu Dhabi Emirate are now served by combined sewerage and irrigation networks, where sewage is collected, treated and used for irrigation. Major low-lying urban areas are also served by networks for storm water and sub-surface water drainage.

Sources

Being a direct result of urbanization, generation of sewage would parallel the distribution and patterns of population densities.

Sewerage Networks

Abu Dhabi Municipality manages an extensive sewerage network (see **Table 3.2.1-B**) that employs three types of pumping stations: submersible, screw, and wet well/dry well (SPC, 1999; p. 40). This network and a similar one managed by Al Ain Municipality serve most of the population of Abu Dhabi Emirate. However, septic tanks still serve a small percentage of the population, and a number of small sewerage networks managed by ADNOC serve some of its concession areas.

Urban Area/s	Approx. Area (hectares)	length (m) having D Sewer iameter (mm)			Pumping main (m) having diameter (mm)			Pumping Stations (No) by Capacity (l/s)		Pipe Material *
		100-500	600-900	1000-2200	100-500	600-900	1000-2200	1-300	301-1000+	
Abu Dhabi City	8700	699,926	29,937	116,767	26,636	16,696	29,056	44	10	GRP, VC, AC, uPVC,
Bani Yas, Al Wathba, Al Nahdha, Al Khatem		280,312	4,284	3,265	29,284	3,440	0	26	1	GRP, VC, uPVC, RC
Khalifa Cities, Al Raha Beach, International Airport	7000	273,523	4,461	3,943	37,264	7,296	0	29	2	GRP, VC, AC, uPVC, RC
Mussafah, Officer's City	5800	358,473	8,002	4,338	30,624	0	1,952	21	1	GRP, VC, uPVC
Shahama, Al Bahia, Al Rahba, Al Samha, Ghantout		188,724	17,119	9,297	24,852	7,784	0	11	0 z0	GRP, uPVC, RC
Western Region **		193,105	1,786	0	29,200	0	0	21		GRP, uPVC, PVC

Table 3.2.1B: Overview of the Sewerage Network Established by Abu Dhabi Municipality, as of 1999

* Abbreviations: GRP= Glass Reinforced Plastic; VC=Vitreous Clay; AC= Asbestos Cement; PVC=Polyvinyl chloride; uPVC= Unplasticized PVC (=PVCu), RC=Reinforced Concrete.

** Western Region = Al Baia, Al Mirfa, Al Sila, Ghayathi, Liwa, Madinat Zayed, Delma Island

Source: SPC (1999).

Note: Table needs updating.

Abu Dhabi's prevailing hot climate, when coupled with long retention times in sewer lines, would naturally lead to the generation of significant odours from sewers. However, odorodour problems in the sewerage network were significantly controlled by Abu Dhabi Municipality by using a combination of techniques (SPC, 1999; p. p. 34, 70):

1. Using manhole covers designed to prevent escape of odours.
2. Installing chemical scrubber deodorizers at major pumping stations.
3. Constructing plants that extract oxygen from air (by molecular sieves that filter out nitrogen) and inject it into the sewage. Three such plants inject 20 tons of oxygen per day into the major sewage pumping mains between Abu Dhabi Island and Mafraq STP. A fourth plant situated at a major pumping station southwest of Shahama aerates the sewage collected from as far north as Al Samha to minimize its septicity on its long journey to Mafraq STP.

The existing sewerage network in Al-Ain is also fitted with odorodour control devices, however complaints of odour are still received (Maunsell, 2004, p. p. 17).

Sewer lines in Abu Dhabi are also exposed to highly corrosive conditions, both externally and internally, due to many factors (SPC, 1999; p. p. 35):

1. Long retention times within sewers, leading to septic conditions and the generation of hydrogen sulfidesulphide. The latter is oxidized, by bacteria present in slimes above normal sewage levels, to sulfuricsulphuric acid, which is a major contributor to the internal corrosion of sewer pipes and other structures of the network.
2. Low alkalinity of the sewage, due to the extensive use of desalinated water having low carbonate content. This factor accelerates the development of acidic conditions and, hence, internal corrosion.
3. Presence of saline groundwater tables, which affect sewer lines from the outside (external corrosion). Naturally, this factor is more significant in low-lying coastal areas.
4. Hot and humid climate, which accelerate both internal and external corrosion.

To counter impacts of these corrosive conditions, Abu Dhabi Municipality relied extensively on the use of GRP (glass- reinforced plastic) as a construction material for the major sewer lines and on the use of PVC (polyvinyl chloride) for smaller sized subsidiary lines (generally not larger than 300 mm in diameter). Up to 3000 km of GRP lines were installed by Abu Dhabi Municipality until 1999. However, asbestos pipes were seldom used as they proved non-resistant to corrosive conditions. (SPC, 1999; p. p. 35, 36, Appendices).

GRP is also used to line the insides of concrete structures of manholes, pumping station sumps, valve chambers, storm water outfalls, and tanks of the treatment plants, to protect them from the internal corrosive action of acidic sewage and constituents. In addition, external faces of underground concrete structures are protected from the highly corrosive saline groundwater in coastal areas by bitumen tanking, GRP and other types of coating. And all structures are subject to periodic rehabilitation (SPC, 1999; p, 27, 35).

Al-Ain Drainage Master Plan (op. cit. Maunsell, 2004, p. p. 17, 26) identified that leakage from sewer pipes may have lead in the past to soil contamination, groundwater contamination and in some cases contamination of drinking water supply pipes, and that the sewerage network should be properly maintained to prevent such contamination.

Sewage Treatment Plants

Most of the sewage generated in Abu Dhabi Emirate is pumped to sewage treatment plants that are mostly operated by Abu Dhabi Municipality (**Table 3.2.1-C**), Al-Ain Municipality and ADNOC Group companies.

Abu Dhabi and the Western Region		
Treatment Plant at	**Year Commissioned**	**Design Capacity (m3/d) ***
Mafraq **	1982 Phase 1	104250
	1997 Phase 2	156375
Al Khatem	2000	1375
Ghantout	Phases 1 & 2*	662
Baynunah	1997	1400
Madinat Zayed	Phases 1 & 2*	10000
Al Mirfa	Phases 1-3*	8000
Al Mirfa Canning factory *		600
Ghayathi	2001	2500
Delma Island		1500
Al Sila		2500
Ghuwiafat		225
Liwa		2500
Abu Al-Abyadh *		195
Sir Bani Yas *		190

Al-Ain *	
Treatment Plant at	**Design Capacity (m3/d) ***
Al-Ain	54000
Compost liquor TP	200
Al-Khazna	650
Al-Hayer	1250
Sweihan	650
Wadi Flaie	840
Al-Quaa	840
Shwaib	1300
Al-Wagan	1960
Al-Faqa	700
Al-Dhahirah	280
Seih Gharabah	42
Remah	1500
Bu Karriyah	900
Seih Gharabah	38

Table 3.2.1C: Sewage Treatment Plants in Abu Dhabi, the Western Region and Al-Ain

Source: SPC (1999) unless otherwise noted.

* As updated by ADSSC (2006)

* * Serves Abu Dhabi City, Bani Yas, Al Wathba, Al Nahdha, Khalifa Cities, Al Raha Beach, International Airport, Mussafah, Shahama, Al Bahia, Al Rahba, Al Samha

Mafraq STP

Mafraq sewage treatment plant is now the largest in Abu Dhabi Emirate, receiving effluents from Abu Dhabi Island and nearby towns on the mainland. It houses two treatment trains, constructed at two phases, with a total treatment capacity of 260,625 m^3/day, equivalent to 900,000 inhabitants (SPC, 1999; p. 29).

The two treatment trains employ similar designs based on activated sludge process with tertiary treatment **(Table 3.2.1- D)**. Chlorine levels in the final effluent are monitored by sensors and other effluent quality parameters are monitored by laboratory analysis. The treated effluent is partly used for greening on-site and the rest is pumped for use in greening elsewhere (SPC, 1999; p. 58-59). Part of the effluent is also diverted to the nearby Al-Wathba Lake, thus making this low lying area an important site supporting migratory birds wintering in Abu Dhabi.

The dried sludge produced from both trains is currently transported to Mussafah Compost Plant where it is mixed and composted with other solid wastes, with the resulting final compost used for greening in the emirate (SPC, 1999; p. 59- 62). However, this plant is expected to stop operating before the end of 2005, and dry sludge will have to be transported directly to the landfill for disposal until a replacement and more modern compost plant is established.

Sewage Treatment (activated sludge process with tertiary treatment)	• Inlet works (screens, macerators, etc.) Primary settling tanks. • Aeration system (with improved design in Phase 2) • Secondary settling tanks. • Sand filtration, with the filters automatically cleaned by air scouring and back flushing. • Chlorination, with chlorine gas dosed after secondary tanks (pre-chlorination) and after sand filters (post chlorination).
Sludge Treatment	• Primary and secondary anaerobic digesters. • Sludge dried in beds then taken for composting at Mussafah compost plant. • Resulting gas mixture is flared.
Effluent Quality (April 1999, after tertiary treatment)	• Biochemical Oxygen Demand (BOD): • 0.9 mg / l • Chemical Oxygen Demand (COD): 17 • mg / l • Suspended solids (SS): 2.4 mg / l • Ammonia-N: 0.5 mg / l • Nitrate-N: 6.6 mg / l • Faecal coliforms: 3 MPN /100 ml • Residual chlorine: 1.6 mg /l

Table 3.2.1D: Treatment processes and effluent quality at Mafraq STP

Source: SPC (1999).

After the second treatment train was commissioned, a programme was started to rehabilitate, overhaul and upgrade the first train. A system for odour control was also introduced. Aluminium domes were added to cover the headworks, primary treatment tanks and gravity sludge thickeners. Gases started to be chemically scrubbed with caustic soda and sodium hypochlorite to ensure near complete removal of odours. New dewatering centrifuges and centreless screws were designed to contain odours, and the enhanced dewatering of solids further reduced drying bed odours (SPC, 1999, p. 62).

Zakher STP

Located about 25 km to the south of Al-Ain City centre, Zakher STP is the second largest in Abu Dhabi Emirate, with a design capacity of 54,000 m^3/day and an actual throughput close to 70,000m^3/day. The plant uses the activated sludge process and tertiary treatment with sand filters to treat sewage from Al-Ain City and its peripheral townships. The raw sewage entering the STP and the final effluent are tested on a daily basis, and final effluent quality is generally high. The treated effluent is stored and used to irrigate municipal landscape areas. Effluent that is surplus to the capacity of the storage tank is pumped to a percolation zone filled with tall grass or, when capacity of the percolation zone is exceeded, onto nearby desert. Sludge from the treatment units is digested, dried (in drying beds), and taken to the compost plant where it is added to the biodegradable waste. (Maunsell, 2004; p. 15, 16).

According to Al-Ain Drainage Master Plan (op. cit. Maunsell, 2004, p. 17, 26) the quality of the influent at Zakher STP has caused concern at times, due to high levels of metals and other contaminants. This probably reflects lack of control over the quality of effluents, particularly trade/industrial effluents entering the sewerage network. Discharges of industrial waste water to the sewerage system should be subject to licensing.

Other STPs

A number of smaller sewage treatment plants serving small populations are operated by Al-Ain and Abu Dhabi Municipalities **(Table 3.2.1-C)**, as well as by ADNOC.

All small treatment plants established by Abu Dhabi Municipality in the Western Region (see **Table 3.2.1-C**) include tertiary treatment and chlorine disinfection to ensure quality and safe use of the treated effluent. Most of them are designed to discharge excess influent sewage to emergency disposal areas in the desert (SPC, 1999; p. 76-83).

There are 14 regional sewage treatment plants serving peripheral communities in Al-Ain region **(Table 3.2.1-C)**. These STPs consist of package treatment plant or secondary treatment units. There is currently a project to upgrade and modernize some of these STPs, including those at Al-Khazna, Dhahirah, Al-Hayer, Al-Saad and Al-Saa. (Maunsell, 2004; p. 16).

The sewage treatment plant at Ruwais housing complex is the largest such plant operated by ADNOC (treatment capacity about 8785 m^3/day; total influent slightly more than 2 million m^3//year in 2004). The incoming sewage is treated at three main stages **(Table 3.2.1-E)**. After primary treatment the flow is diverted into two treatment plants (original and extension), each having two process trains for secondary treatment by a modified extended aeration activated sludge process. The modified process provides an anoxic (oxygen deficient) zone, reportedly to reduce nitrate level in the wastewater. Following sand filtration and chlorination, the effluent is used to irrigate landscaping area of the housing complex. Effluent quality is checked by continuous monitoring by a chemical laboratory at the STP **(Table 3.2.1- F)**. A Thermal Drying Unit is proposed to be added to the STP to handle the increasing quantity of sludge being produced. (ADNOC, 2005b).

Primary Treatment	Secondary Biological Treatment	Tertiary Treatment
• Flow measurement • Head works • Screenings • Grit removal/ Dewatering/ Disposal • Flow Distribution	• Aeration Basin consisting of: - Aeration Zone - Anoxic zone • Clarifier Tank • Clarifier Tank • Return Sludge Pumps	• Effluent Aerator • Flocculation Tank • Settling Tank • Sand filtration • Flow measurement • Chlorine Contact • Tank • Storage Basin

Table 3.2.1E: Process details at Ruwais STP

Source: ADNOC (2005b)

Parameter	Raw Sewage	After Secondary Treatment	After Tertiary Treatment
BOD (mg / l)	250	12.5	<10
TSS (mg / l)	250	12.5	<10
Ammonia (mg / l)	25	1.25	<0.5

Table 3.2.1F: Characteristics of effluents handled by Ruwais Sewage Treatment Plant

Source: ADNOC (2005b)

Other smaller treatment plants belonging to ADNOC Group companies are distributed at their various locations (land installations, camps, and rigs; offshore rigs and vessels; and on islands) (ADNOC, 2005b). Larger plants occur at Das Island (1350 m^3/d), Habshan (800 m^3/d) and Asab (500 m^3/d), with smaller plants ranging down to few m3/d occurring at the other locations. Biological treatment methods are used at most locations, including the larger plants at Das Island, Habshan and Asab, with some physical-chemical methods used at few locations (*e.g.* Mubbaraz Island, Bunduq, and some offshore rigs). Treated effluents generated on the mainland or on islands are used mostly for irrigation and landscaping, with excess effluents discharged to the desert or to nearby mangrove areas. Treated effluents generated from offshore sources (rigs and vessels) are discharged to the sea. Quality of treated effluent is monitored regularly. Most of the STPs are managed by third party contractors.

Irrigation Networks

Treated sewage effluents have been used in irrigation since 1973, when the first STP was commissioned. This practice continued and expanded when Mafraq and other STPs were commissioned, through the addition of more lines, reservoirs and pumping stations **(Table 3.2.1-G)**. The capacity of 48 storage reservoirs on Abu Dhabi Island exceeds 26 million gallons **(Table 3.2.1-H)**. A new distribution centre was added on the Island in 1987 (SPC, 1999; p. 45) followed in about 2000 by a new central irrigation pumping station at Mafraq. The latter is the largest of its kind in the UAE (capacity 3000 l/s) and controls delivery of treated effluents to the mainland treated effluent distribution network (SPC, 1999; p. 51).

In addition to the network established by the SPC, ADM Agriculture Section installed a considerable number of small storage tanks and booster pumps at various locations to overcome problems of low pressure and to facilitate various planting programmes (SPC, 1999; p. 45). The treated effluent is used for the irrigation of ornamental plants and crops not intended for human consumption, including the Golf Course west of Al Raha Beach, camel forage within Al Wathba camel race track, and plantings along city streets and inter-city highways (SPC, 1999).

Urban Area/s Served	Distribution Main (m) having Diameter (mm)			No. of Reservoirs	No. of Pumping Stations	Pipe Material *	Treated Effluent from STP at
	100-500	600-900	1000-1500+				
Abu Dhabi City	87,978	4,085	32,832	55	4	GRP, PVC, AC, DI, PVCu	Mafraq
Bani Yas, Al Wathba, Al Nahdha, Al Khatem	17,593	29,034	14,979	1	2	GRP, uPVC	Mafraq
Khalifa Cities, Al Raha Beach, International Airport	905	15,719	310	7	0	GRP, AC	Mafraq
Shahama, Al Bahia, Al Rahba, Al Samha, Ghantout	55	550	150	4	1	GRP	Mafraq
Western Region **	43,502	0	0	3	0	GRP, AC	Jebel Dhana Hotel, Baynunah, Madinat Zayed, Al Mirfa, Ghayathi, Delma Island, Al Sila, Liwa

Table 3.2.1G: Overview of the Irrigation Network Established by the SPC of Abu Dhabi Municipality, as of 1999

*Abbreviations: GRP= Glass Reinforced Plastic; AC= Asbestos Cement; RC=Reinforced Concrete; PVC=Polyvinyl chloride;

uPVC= Unplasticized PVC (=PVCu), DL= Ductile iron

** Western Region = Al Baia, Al Mirfa, Al Sila, Ghayathi, Liwa, Madinat Zayed, Delma Island

Source: SPC (1999).

Location	No. of Reservoirs Having Capacity (in Gallons) of			
	300000	1000000	1500000	2500000
At Distribution Center/s	-	2	5	2
Outside Distribution Center/s	39	-	-	-
Total Capacity	11700000	2000000	7500000	5000000

Table 3.2.1H: Treated Effluent Storage Capacity on Abu Dhabi Island

Source: SPC (1999).

A similar system is operated by Al-Ain Municipality, whereby 14 million gallons / day of treated wastewater are used by the Gardens Department to irrigate reservations and roadside vegetation within Al-Ain region through a distribution network and drip irrigation system (Maunsell, 2004; p.13). However, the amounts of treated wastewater used for municipal irrigation purposes are supplemented by significant amounts of groundwater (*ibid.*).

Drainage Networks

Drainage networks have been developed for Abu Dhabi Island, major townships along the coastline, and some townships along the Abu Dhabi-Al Ain highway, because of the high water table in these low-lying areas. ADM SPC

developed the networks outside Abu Dhabi Island and a small part of the network on the Island **(Table 3.2.1-I)**, whereas ADM Roads Section developed most of the network on the Island, including about 600 km of pipes (diameter 300 to 2400mm), 23 pumping stations, and 32 sea outfalls until 1999 (SPC, 1999; p. 44). Some of these outfalls drain inland areas as far as Al Wathba and Bani Yas. One of the drainage lines outfalling into Mussafah southern channel passes next to Mafraq STP and can act as emergency overflow from the works if they become hydraulically overloaded (SPC, 1999; p. 50)In addition, two detention basins were established at low lying locations in Bani Yas and Al Wathba, to reduce pipe diameters and cost. They were developed as parks offering suitable environment for birds and improving amenities in these areas (SPC, 1999; p. 50).

Urban Area/s Served	Distribution Main (m) having Diameter (mm)			Structures (No) by Type			Pipe Material *
	100-500	600-900	1000-2400+	Inlets	Pumping Stations	Sea Outfalls	
Abu Dhabi City Bani Yas, Al Wathba, Al Nahdha, Al Khatem	23,421 27,661	1,607 6,687	200 33,618	280 0	0 2	1 1	GRP, VC, AC, uPVC, RC GRP, AC, RC
Khalifa Cities, Al Raha Beach, International Airport	3,203	17,554	42,047	30	0	3	GRP, RC
Mussafah	49,262	60,746	36,480	935	0	8	GRP, VC, uPVC
Shahama, Al Bahia, Al Rahba, Al Samha, Ghantout	62,263	16,722	35,079	394	0	3	GRP, uPVC, RC, DI

Table 3.2.1I: Overview of the Drainage Network Established by Abu Dhabi Municipality, as of 1999

* Abbreviations: GRP= Glass Reinforced Concrete; VC=Vitreous Clay; AC= Asbestos Cement; RC=Reinforced Concrete; uPVC= Unplasticized Polyvinyl chloride

Source: SPC (1999).

Because of the low height of Abu Dhabi Island and its surrounding areas, stormwater pipes are generally below sea level and some of the sea outfalls are submerged (SPC, 1999; p. 56). They operate when there is hydraulic difference between stormwater elevation in the inlet at street level and sea surface at the outlet (a difference of about 2 meters). At the outfalls, flap gates prevent backflow from the sea, and pumping stations enable the main lines to be dewatered when maintenance is required (SPC, 1999; p. 44).

Because of the high water table in the Abu Dhabi area, civil constructions that require excavation must initially de-water the work area. The resulting groundwater is highly saline and cannot be discharged into the public sewer, because it will negatively affect the quality of the treated effluent discharged from Mafraq STP. Instead, this water is discharged to the sea through the stormwater drainage network, after getting a temporary discharge license from the concerned authorities (SPC, 1999; p. 93). Presence of the stormwater drainage system in Abu Island also allowed installation of subsurface drainage systems that lower the naturally highly saline groundwater table thus prolonging the life of roads, buildings and underground utilities and improving tree and grass planting (SPC, 1999; p. 44).

Telemetry and Control Systems

ADM SPC developed a computer-based Supervisory Control and Data Acquisition (SCADA) system to remotely control and monitor the performance of its sewerage, irrigation and stormwater networks. This system is interfaced with the computerized control and monitoring scheme for Mafraq and other STPs operated by ADM. Overall, the system consists of four control centres, six mini-SCADA systems and more than 250 Remote Terminal Units (RTUs) (SPC, 1999; p. 31, 102- 103).

In addition, the SPC operates an Asset Information and Management System (AIMS) that includes a Ground Conditions Program (GCP). The latter is an integration of several applications, including geophysical investigations instrumentation, GIS technology, satellite and aerial image interpretation, and construction and borehole records (SPC, 1999; p. 38-39).

Issues, Trends, and Future Actions

In general, the sewage generated in Abu Dhabi Emirate is managed very well at the present, mainly through the collective efforts and policies of the Municipalities. Most of these efforts and policies should be commended and continued, including those related to the following:

- The use of treated effluents for irrigation purposes. However, standards should be introduced for treated wastewater quality, to protect human health and groundwater resources, which may be affected if water of low standards is used on land or percolates into groundwater reserves.
- Odour control at Abu Dhabi sewerage network.
- Protection of sewerage networks and structures from corrosive factors.

However, some policies and practices need to be revised, for example:

- Odour control at Al-Ain sewerage system should be enhanced.
- Composting of dry sewage sludge with municipal wastes should stop, and the sludge should be disposed of by other means.
- Discharges of industrial wastewater to the sewerage system should not be allowed unless they meet certain minimum stan dards.

Projection of future generated quantities of sewage requires knowledge of the rate of population growth. The latter is difficult to estimate at present, because of recent changes in policies affecting employment, housing and real estate sectors. However, sewage quantities will undoubtedly increase, in view of the announced plans to establish some very large housing and urban projects (e.g. at Saadiyat Island, Reem Island, Raha Beach, and Hedairiyat Island).

A Drainage Master Plan for Al-Ain region, completed in 2003, identified that the current sewage treatment facility at Zakher, although meeting current needs of the city, cannot adequately treat the projected sewage flows to the year 2025. It proposed to construct a new STP at Al-Saad to treat flow from the northern city catchment, and to refurbish / upgrade the STP at Zakher to treat the flow from the southern city catchment (Maunsell, 2004, p. 17).

Because of their potential environmental impacts, future waste facilities should be subjected to environmental permitting through an appropriate level of EIA, especially that more of these facilities are likely to be established and run by the private sector.

3.2.2 Industrial Liquid Discharges

Industrial liquid discharges may contain a variety of pollutants that make them hazardous (Section 2.4). Discharges of most environmental significance in Abu Dhabi Emirate may be classified into the following:

1. Discharges into the sewerage networks.
2. Discharges to land.
3. Discharges to the marine environment from power and desalination plants.
4. Discharges to the marine environment through coastal outfalls.
5. Surface discharges from the oil Sector
6. Deep well injection of effluents.
7. Discharges of drilling mud from well operations.

The following subsections would discuss available information related to the sources and management of these discharges and effluents, together with the quantitative data available for some of them. The last two subsections would address levels of pollutants observed in Abu Dhabi's marine environment, and issues, trends and future actions related to industrial liquid discharges. The role of emergency preparedness and crisis management in protecting against incidents involving industrial effluents or other causes are discussed in Section 3.2.3.

Discharges to Sewerage Networks

Industrial discharges generated within Greater Abu Dhabi Area are required to be treated to certain standards before discharge into public sewers. Pre-treatment may range from grease traps to special plants designed to serve particular industries (SPC, 1999; p. 34). Sludge resulting from on-site treatment is usually taken by private sector companies for disposal elsewhere, usually to landfills.

A similar approach is adopted in Al-Ain, where industries are mostly rural or agricultural. Effluents from slaughterhouses receive primary treatment and screening before being discharged into the sewer. Other industrial effluents are served by grease traps or partially treated before discharge into the sewer (e.g. by primary settlement in case of some chicken slaughterhouses) (Maunsell, 2004).).

Occasionally, some industrial effluents are given to environmental service providers for treatment offsite by relatively simple physico-chemical methods, e.g., by oil separators, and neutralization for the treatment of acids and alkalis. Effluents are expected to be treated to meet criteria for discharge into the sewerage network, which is usually allowed at some pre-designated points equipped with simple testing facilities.

Discharges to Land

There are several examples of effluents that end up with land disposal, for example:

- Effluents of a canning factory at Abu Samra are reportedly discharged to the desert with no treatment (Maunsell, 2004).
- Effluents of a large Dairy Farm in Al-Ain are collected in large evaporation ponds that allow effluent to seep into the ground. Inadequacy of this method prompted Al-Ain municipality to plan for a full treatment plant for this farm (Maunsell, 2004).
- Effluents of some other dairy farms in Al-Ain which are collected in septic tanks before discharge to the desert. These effluents could be very polluting because of their high content of BOD, ammonia and nitrate, and may cause contamination to the land and pollution to groundwater reserves. (Maunsell, 2004).

- About 800m3/day of liquid wastes that are generated in Greater Abu Dhabi and become disposed of at Al-Dhafra landfill, usually in pits, including large volumes of oily wastes. Disposal of liquid effluents to solid waste landfills will interfere with their operations, and infiltration of effluents into the ground would potentially contaminate groundwater (Fichtner, 2005a).

Discharges from Power and Desalination plants

Several large thermal power and desalination plants occur along the coastline of Abu Dhabi Emirate, together with some small power plants in other areas (Table 3.3.3-A). In addition, there are several smaller RO desalination plants operated for certain purposes at different locations. Some of these plants withdraw seawater from the open sea, whereas others withdraw saline groundwater from wells (e.g. by the armed forces; EAD, 2005f).

Coastal RO units usually discharge their effluents back to the marine environment. RO units withdrawing saline groundwater may discharge their effluents to the marine environment, if nearby, or to the desert (EPD, 2005f). RO effluents would be of higher salinity than their feedwater, and may contain chemicals used to flush pipelines or to clean or preserve RO membranes, e.g. sodium compounds, hydrochloric acid, citric acid, alkalines, polyphosphate, biocides, copper Sulphate, acrolein, propylene glycol, glycerine, or sodium bisulphite (EAD, 2002).

Impacts of RO effluents discharged to the marine environment would depend on effluent quality and characteristics of the receiving water body. Effluents discharged to the desert may percolate into ground or evaporate leaving a crust of salt, thus affecting suitability of soil for certain uses. Impacts on soil may be eliminated by collecting effluents and drying them in a series of large impermeable ponds made of concrete or lined with plastic. The salt that would accumulate can be collected for disposal elsewhere, or for use in some applications (EPD, 2005f).

Thermal power and desalination plants located along the coastline circulate large quantities of seawater for cooling purposes and use smaller quantities as source water. Contaminants in the resulting effluents would depend on the technology used; the quality of the intake water; the pre-treatment methods used, and the quality of water produced. In general, discharges may have the following potentially adverse qualities (EAD, 2002):

- Salt concentrations, temperatures and/or turbidity levels above those of receiving waters. Organics and metals that are contained in the feed water may also be concentrated through the desalination process.
- Oxygen levels below those of receiving waters, e.g. due to de-aeration to reduce corrosion in distillation plants.
- Chemicals from pre-treatment of the feed water, e.g. biocides, sulphur dioxide, coagulants (e.g. ferric chloride), carbon dioxide, polyelectrolytes, anti-scalants (e.g. polyacrylic acid), sodium bisulphite, antifoam agents, and polymers.
- Metals that are picked up by the brine in contact with plant components and pipelines.

Dissolved oxygen, temperature, and salinity are considered the three most important determinants for the growth and survival of marine life (EAD, 2002). Impacts of changes in these determinants may even be larger in Abu Dhabi coastal areas, where species are usually exposed to naturally higher salinities year-round and higher temperatures in summer.

As part of their environmental permits, power and desalination plants are required to monitor quality of the seawater taken, effluents discharged through outfalls, and ambient seawater occurring in the vicinity of the outfalls. They are also required to compare results to requirements of the federal environmental law and byelaws, and to take corrective actions whenever possible. Results of monitoring activities contained within these reports could not be reviewed and synthesized within the relatively short timeframe available for producing this paper.

At present, all power plants (except Shuweihat) are equipped with conductivity and temperature data loggers (CTDs) to monitor quality of seawater in their intakes and outfalls. ADWEA also has a hydrodynamic water quality model to predict changes offshore and nearshore in the vicinity of the power plants. Data can be made available to other parties upon approval of ADWEA management.

Discharges from Coastal Outfalls

Discharges to the marine environment through outfalls from onshore industries and other activities (e.g. hydro-testing of pipelines) are either prohibited, or allowed in strict compliance with requirements of the federal environmental byelaws and permits issued by EAD. Other outfalls along Abu Dhabi coastline are of different types (Section 3.2.1 – See Figure 3.2.2-A). Emergency sewage outfalls seldom operate because of the high efficiency of the sewerage network and associated treatment plants. However, stormwater outfalls may discharge pollutants to the marine environment during episodes of rain (e.g. oily residues, suspended solids, etc.) or as a result of groundwater dewatering during infrastructure development in contaminated shallow coastal areas.

Occasionally, fish kills were reported in Abu Dhabi coastal areas, including within the narrow and shallow channels along Mussafah industrial area in October 2003 and September 2004 (Figure 3.2.2-B). Investigations by EAD at the time could not establish a link with specific pollution sources. Water shallowness, extreme temperatures, algal blooms and oxygen depletion were suspected as causative factors in at least one of the cases.

To assess impacts of coastal outfalls on the adjacent marine environment, EAD started a programme to regularly monitor the occurrence and quality of discharges from the outfalls around Mussafah and Abu Dhabi Island. Any high results are investigated.

Figure 3.2.2A: An outfall discharging along Mussafah Industrial Area

Figure 3.2.2B: Dead fish in a coastal marine channel

Surface Discharges from the Oil Sector

The quantities and fate of surface discharges from the oil sector in 2004 are summarized as follows (ADNOC, 2005c):

- All harmlesss process effluents from offshore facilities (i.e. saine water from water makers and sewage treatment effluents) are analyzed before disposal to the sea.
- Onshore sewage treatment effluent is used to irrigate camp and facility gardens.
- Some 6.5 million m3/day of clean process and cooling water are discharged to sea, with major outlets at Ds Island, Ruwais and Umm Al-Nar. All outlets are analyzed frequently for harmful components. Potential localized environmental effects (e.g. slightly higher seawater temperature and salinity) have been analyzed, assessed and are considered acceptable.

Deep Well Injection

This method is available only to ADNOC group companies. Starting with 2003, all onshore and offshore produced water (325,000 m3/day) is re-injected into deep reservoirs, including water that is re-injected for reservoir pressure maintenance. All harmful process effluents (12,300 m3/day) are also injected into deep disposal wells (ADNOC, 2005c). No data are available on the composition of the latter effluents.

Well Drilling Mud

The fate of drilling mud used by ADNOC Group companies in 2004 and their associated effluents is summarized as follows (ADNOC, 2005c):

- Oil-based mud is used only in onshore drilling operations. All mud and cuttings (60 m3/day) are transported to a reconditioning and recycling facility for total treatment and recycling with a zero discharge. Harmless drilling water (155 m3/day) is disposed of into desert evaporation ponds, and the rest of drilling water (435 m3/day) is routed to the recycling facility for cleaning and reuse.
- Only water-based mud is used in offshore drilling and all mud and cuttings (185 m3/day) are disposed of in the sea.

Pollutant Levels in the Marine Environment

There are limited published reports on the levels of pollutants in the marine environment.

EAD performed limited measurements around Abu Dhabi Island in 1998-1999, but data are not available for review.

FEA and the Marine Environmental Laboratory of the IAEA determined levels of heavy metals (Cd, Pb, Al, V, Cr, Fe, Ni, Cu, Zn and Hg) and petroleum hydrocarbons in sediments, fish and bivalves collected along the coastlines of the UAE in late 2003 (FEA, 2004). Compared to the other locations studied, sediments opposite Umm Al-Nar port showed clear indications of localized anthropogenic contamination with petroleum hydrocarbons (up to 124 ug/g ROPME oil equivalents), mercury (up to 0.82 ug/g) and copper (up to 47.4 ug/g). Compared to levels worldwide, levels of heavy metals in sediments at this site were still lower than reported levels at polluted sites, whereas petroleum hydrocarbons indicated a moderate level of pollution. Levels of Hg (<1 ug/g) and polyaromatic hydrocarbons in the flesh of the fish posed no risk to human consumers.

In view of the limited available knowledge, EAD started a programme to monitor the ambient (offshore and nearshore) marine environment. In addition, the environmental permitting process at EAD requires project proponents and consultants to perform baseline surveys and monitoring programmes and to submit the resulting data in printed as well as in electronic non-pdf format. A mechanism is required to facilitate the incorporation of these data into a comprehensive environmental database. Meanwhile, the data contained within EIA reports could not be reviewed and synthesized within the relatively short timeframe available for producing this paper.

Issues, Trends, Future Actions

Some industrial discharges are being disposed of by inappropriate methods. New policies, procedures or facilities are required to better control these waste streams.

Disposal of liquid effluents to landfills should be stopped as soon as possible, and industrial and other effluents should be treated to a level that allows them to be discharged to sewerage networks or to be used for irrigation. Discharges to the desert should also be stopped unless complying with certain discharge standards, e.g. those set by ADNOC (2004).

There are limited published reports on the levels of pollutants in the marine environment. Programmes started by EAD are likely to close this gap.

3.2.3 Oil spills

Definition

Crude oil may affect marine organisms and ecosystems in different ways, including through toxic effects of its lighter aromatic hydrocarbons. Impacts are potentially more significant on shallow and more productive coastal areas, such as mangroves, seagrass beds and tidal flats, which are all extensive in Abu Dhabi Emirate.

Quantities

The most significant oil spill in Abu Dhabi Emirate to date occurred in 2000 (Tanker “Al-Jaziya” opposite Al-Saadiyat Island). In 2004, a total of 9.2 m3 of crude oil were spilled in minor onshore (19) and offshore (1) incidents (ADNOC, 2005c).

Management

Because of their potential negative impacts, efforts are required to prevent oil spills from occurring, and also to combat them once they occur, through oil spill contingency plans.

A national plan for marine environment protection was put by FEA in 1999 in cooperation with concerned federal and local bodies. The plan divided the UAE coastline into six geographic zones, each managed by a local committee of key stakeholders (Coast Guard, oil companies, port authorities, municipalities, Civil Defense, etc.). The plan was to be implemented on two levels: A national level implemented by FEA, and a local level managed by the local committee (Anonymous, 2004; p. 21). More recently, a federal crisis management plan prepared by the Civil Defense was adopted, aiming to tackle all types of emergencies throughout the UAE.

However, both federal plans are not implemented in practice, for different reasons, and oil spills continue to be combated in Abu Dhabi mainly by ADNOC and EAD. EAD has developed a system to receive notifications of incidents, monitor developments, and follow up environmental corrective and site rehabilitation actions, whereas ADNOC continues to be in charge of field combating operations, in cooperation with specialized companies where needed.

All power plants in Abu Dhabi (except Shuweihat) are equipped with air bubble barriers and floating booms for protection against oil spills. If these measures are overwhelmed the affected plant will have to be shutdown. To further protect against this happening, ADWEA employs an oil spill trajectory modelling software to predict the movement of oil spills to enable mitigation of their impacts before reaching the power plants.

Issues, Trends, Future Actions

To meet the growing international demand, oil production in Abu Dhabi Emirate is likely to increase in the coming years, thus increasing probability for the occurrence of oil spills. More stringent emergency plans are required to minimize the overall risks of this happening.

In 2005, a higher committee for crisis management was established in Abu Dhabi Emirate, headed by EAD. The committee decided to develop an emergency and crisis management system that is implemented through public-private participation, i.e. through specialized private company/companies that is/are guided by the government sector. Implementation of this system is expected to commence in 2006 with a consultancy study that shall survey the existing situation in the Emirate (regulations, equipment inventories, available resources, etc.) and develop and propose a strategy and full system for crisis management.

3.2.4 Ship Ballast Waters

Definition

To keep them balanced when empty, older oil tankers used to carry large amounts of seawater in their tanks, and to discharge this water before they are filled with a new cargo of oil. The discharged "ballast water" used to contain oil (at about 0.1 5%) and may contain exotic marine species that can negatively affect native species and ecosystems (Anonymous, 2004). This problem is not encountered in newer tankers, which are equipped with facilities that do not cause polluting discharges to the marine environment.

Quantities

Data are not available at present on quantities of ballast waters discharged from oil, tankers, or on other liquid discharges from ships.

Management

Ships and tankers reporting to UAE ports are inspected and certified by UAE Ministry of Communications (MOC) for compliance with the latest applicable national and international requirements, specifications and standards, including aspects related to marine discharges. According to Al-Sarri (2004), all ships and tankers operating in UAE at present are appropriately certified and equipped.

UAE federal environmental bylaws and MarPol 73/78 Treaty require port authorities to establish facilities to receive wastes of ships and tankers, in order to help them dispose of these wastes safely. UAE federal environmental law also prescribes penalties for littering and disposal of hazardous wastes into the local marine environment. These provisions are enforced mostly by the Coast Guard and port authorities.

In September 2003, GCC ministers of the environment approved the establishment of 12 waste reception facilities throughout the region, including three in the UAE, located at Abu Dhabi and Fujairah. However, these facilities are not established yet.

Issues, Trends, Future Actions

Statistics are required on quantities of ballast water discharged into the local marine environment, and their future projections.

Waste reception facilities at ports should be established as soon as possible, together with implementation of relevant UAE byelaws.

Older tankers should be banned from entering the semi-closed gulf and reaching Abu Dhabi, and all ships should continue to be strictly inspected for compliance with modern specifications and standards.

3.2.5 Leaking Underground Storage Tanks (LUST)

Definition

The term "leaking underground storage tanks" can be used to designate tanks containing liquid materials of all types, but is most often used to refer to tanks containing petroleum products.

Leakage of a relatively small quantity of a refined petroleum product may contaminate a relatively large body of groundwater and make it unusable for drinking or for other purposes. Stored petroleum products may also contain additives (*e.g.* MTBE) that are more water soluble than petroleum hydrocarbons, thus contaminating an even larger body of groundwater.

Sources and Quantities

ADNOC-DISTRIBUTION is the sole distributor of liquid petroleum products throughout Abu Dhabi at present, through filling stations containing underground storage tanks (USTs). However, USTs may also be installed by some other parties to hold liquid materials for different purposes.

There are no data so far on pollution cases in Abu Dhabi Emirate involving USTs of ADNOC-DISTRIBUTION or the other parties.

Management

Traditionally, leaks from USTs are detected through daily manual gauging coupled with inventory control methods. Manual gauging would provide a daily accurate measurement of a tank's contents, and inventory control would perform daily calculations to prove that the tank has not leaked (ADMA-OPCO, 2005).

Recognizing the need to detect the slightest leaks as soon as possible, ADNOC-DISTRIBUTION started to introduce an automated tank gauging system (ATG) at its filling stations. In addition to its environmental benefits, the system provides for better inventory of stock, prevention of overfills, and protection from misuse or theft. Potential systems were tested and evaluated in 2000 / 2001, and 39 filling stations have been fully equipped with ATG at a cost of about $10,000 per station on average. ATGs shall gradually be installed at all petrol filling stations (ADNOC-DISTRIBUTION, Undated).

If an underground leak is detected, pre-approved HSE safety plans call for taking certain procedures immediately (ADMAOPCO, 2005). These procedures would secure the site, employees and the immediate environment, but are not likely to address longer term impacts on groundwater quality.

Issues, Trends, Future Actions

There are no data at present regarding impacts of USTs on groundwater quality. Any problems with USTs of ADNOC-DISTRIBUTION are likely to decrease with full introduction of ATGs at its filling stations. The issue needs further examination and assessment.

3.2.6 Residues of Pesticides in Water

Use of pesticides in agriculture and for public health purposes in Abu Dhabi Emirate (Section 3.1.9) may affect only groundwater, if any, because the Emirate has no permanent surface water streams or bodies, and any inland agricultural runoff will either evaporate or percolate into the soil. The ability of a pesticide to reach groundwater with irrigation water or rainwater would depend on many factors, including characteristics of the pesticide (solubility, adsorption, volatilization, degradation half-life), soil (sand vs. silt vs. clay content; porosity; organic carbon content) and location (groundwater table, depth of unsaturated zone, geological and climatic conditions).

Two recent studies assessed levels of pesticides in groundwater of Abu Dhabi Emirate. Albehaisi et al. (2003) detected no residues in 51 groundwater samples collected from Abu Dhabi Western Region in 1999 and 2001. Between October 2004 and mid-2005, EAD (2005b) analyzed for 28 pesticides and degradation products **(Table 3.2.6-A)** in 228 samples collected from wells throughout the emirate (**Figure 3.2.6-A**), as part of a UAE-wide study initiated and funded by the Federal Environmental Agency. Most of the target pesticides were internationally and locally banned, and most were chlorinated. Of the target compounds, residues of only p,p'-DDD or p,p'-DDE were detected in three samples, but these residues were not confirmed in duplicate samples collected from the same source locations as well as from 3-4 additional locations adjacent to each source location. Reasons for the initial positive results are not clear, and these positive results should not be considered any further.

Chemical Class	Pesticide Common Name	Use	Locally Banned Pesticides
Chlorinated	Aldrin	Insecticide	Banned
	a-Hexchlorocyclohexan	Insecticide	Banned
	b-Hexchlorocyclohexan	Insecticide	Banned
	d-Hexchlorocyclohexan	Insecticide	Banned
	p,p-DDD	*	*
	p,p-DDE	*	*
	p,p-DDT	Insecticide	Banned
	Dieldrin	Insecticide	Banned
	Endosulfan I	Insecticide	Banned
	Endosulfan II	Insecticide	Banned
	Endosulfan sulphate	Insecticide	
	Endrin	Insecticide	Banned
	Endrin aldehyde	*	*
	a-Chlordane	Insecticide	Banned
	g-Chlordane	Insecticide	Banned
	Heptachlor	Insecticide	Banned
	Heptachlor epoxide	*	*
	Methoxychlor	Insecticide	Banned
	trans-Nonachlor	Insecticide	
Nitrogen-Containing	Atrazine	Herbicide	Banned
	Simazine	Herbicide	Banned
Pyrethroid	cis-Permethrin	Insecticide	
	trans-Permethrin	Insecticide	
Others	Alachlor	Herbicide	
	Chlorothalonil	Fungicide	Banned
	Chlorobenzilate	Acaricide	Banned
	Chloroneb	Fungicide	
	Dacthal	Herbicide	

Table 3.2.6A: Target Pesticides in Groundwater Samples

* Pesticide degradation product

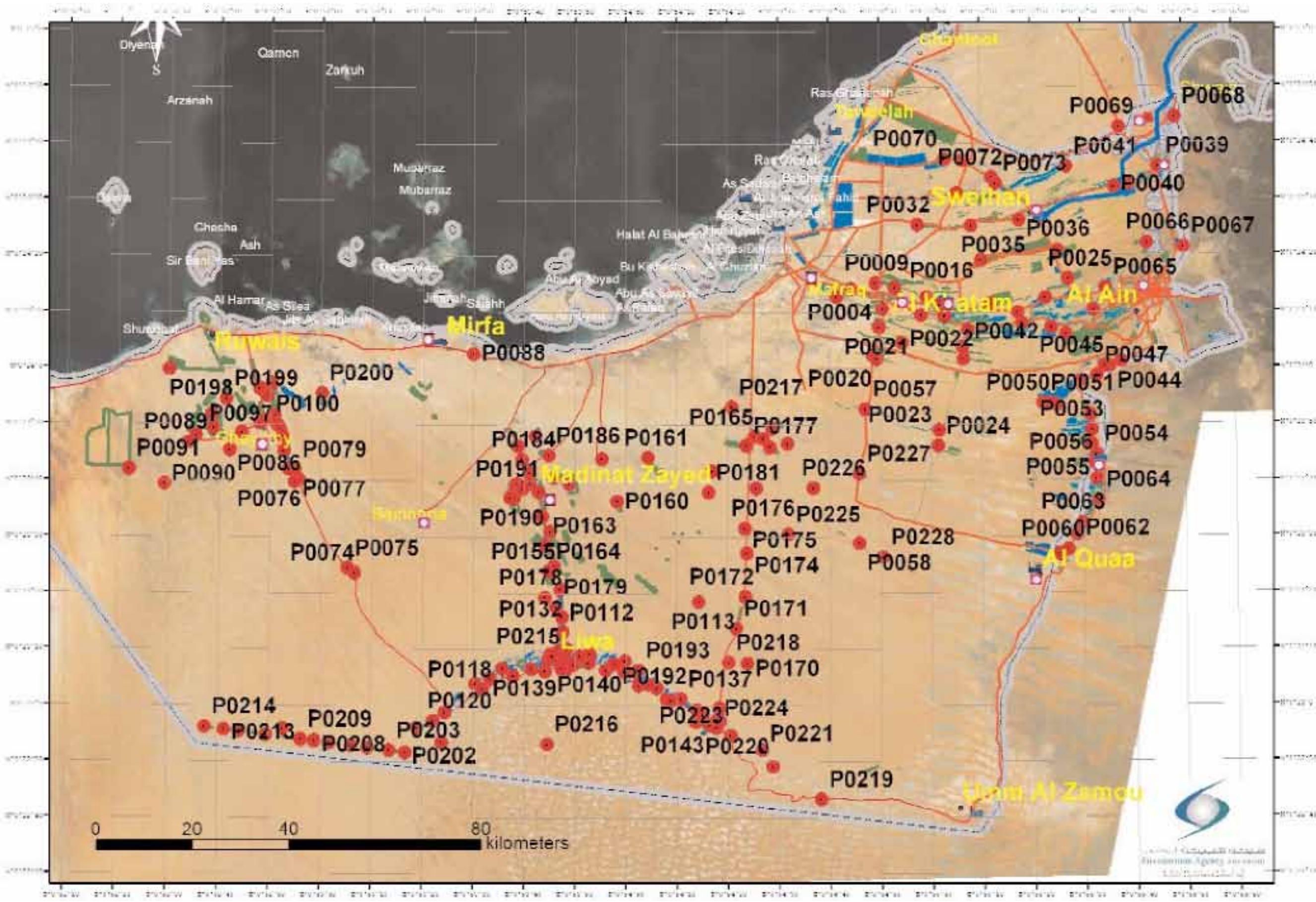


Figure 3.2.6A: Groundwater sampling locations (EAD, 2005b).

Several interrelated factors may contribute to the observed lack of residues in groundwater samples (see **Table 3.2.6-B**). Further studies are required to assess the role of individual such factors. A full assessment of the occurrence of pesticides in groundwater would also require a longer monitoring period and the analysis of a larger number of pesticides that are used in the Emirate (EAD, 2005c).

- That most target pesticides are banned means no new uses or recent sources for them.
- Ability of soil particles to adsorb pesticides reduces their mobility and potential to reach groundwater, and keeps them in surface layers of soil.
- Depth of groundwater table in most areas increases thickness of soil that acts to adsorb pesticides.
- High evaporation rates in the region and modern irrigation methods reduce infiltration of irrigation water into the groundwater.
- High ambient temperatures and high rates of solar
- irradiance throughout the year subject pesticides to evaporation and photo degradation reactions
- Tilling and irrigation of agricultural soil subject buried pesticide residues to anaerobic conditions that may accelerate degradation of some pesticides (*e.g.* DDT).

Table 3.2.6B: Factors Potentially Affecting Levels of Pesticides in Groundwater From EAD (2005c)

3.2.7 Residues of Fertilizes in Water

Background

Fertilizers provide the nutrients needed for plant growth (*e.g.* the nitrate ion) either directly (*e.g.* by using ammonium nitrate, a chemical fertilizer), or indirectly (through degradation of urea and organic fertilizers). They are particularly indispensable for agriculture and gardening when the soil is poor, as it is the case in most of Abu Dhabi Emirate.

Use of fertilizers in Abu Dhabi Emirate is likely to affect only groundwater, because the Emirate has no permanent surface water streams or bodies, and any inland agricultural runoff will either evaporate or percolate into the soil. Of the different constituents of fertilizers, it is usually the nitrate ion that receives most attention, because it is water-soluble and can move readily with water through the soil into groundwater. When contaminated groundwater is consumed the nitrate ion would be converted in the digestive track into nitrite ion followed by binding with blood proteins to form methaemoglobin, a conversion that would impair capacity of blood to transport oxygen. WHO drinking water quality guidelines for nitrate and nitrite are 50 and 0.1 mg/l, respectively.

Management of Fertilizers

Import, handling and use of chemical and organic fertilizers are controlled on the federal level by MAF, which is responsible for the following:

- Permitting of factories and traders.
- Issue of import permits for organic and inorganic fertilizers.
- Customs release operations and inspection at points of entry, to control and monitor the quantity and quality of imported fertilizers.
- Inspection of factories and trading establishments.

MAF is assisted in implementing these tasks by local concerned authorities, including EAD in Abu Dhabi Emirate. In particular, all fertilizer manufacturing plants in Abu Dhabi Emirate will have to have environmental permits from EAD.

Quantities of Fertilizers

Figures on the import, manufacture and consumption of chemical and organic fertilizers in Abu Dhabi Emirate were not readily available to the authors, but can be estimated based on:

- Import permits issued by MAF.
- Release operations at POE as documented by MAF, EAD and Abu Dhabi Customs.
- Factory production capacities as provided during factory environmental permitting or environmental inspection.

Levels in Groundwater

The 228 groundwater samples collected by EAD (2005b) for pesticide residue analysis (Fig. 3.2.6-A) were also analyzed for levels of total dissolved solids (TDS) nitrate and nitrite. During field work water temperature, conductivity, and pH were measured in situ, together with well depth.

Levels of TDS in the collected samples were high in general, ranging from 470 to 32400 mg/l (EAD, 2005b). Several factors may contribute to these high levels, notably excessive withdrawal and the resulting upconing of brackish and saline water beneath the heavily pumped freshwater (Maunsell, 2004; p.12).

Nitrates were detected in almost all the samples (detection limit 0.01 mg/l nitrate-N), with levels in 80% of the samples exceeding WHO guideline value for drinking water (50 mg/l of nitrate). Nitrites were detected in only 13 samples (detection limit 0.01 mg/l nitrite-N) at levels ranging up to 0.38 mg/l (of nitrite). Levels of nitrate were highest in samples taken from the vicinity of farms, suggesting an association with the use of fertilizers (EAD, 2005b). Similarly, Maunsell (2004; pp. 10, 12) warned of increased levels of nitrates and chromium in some groundwater reserves in the Eastern Region.

Issues, Trends and Future Actions

Demand for organic and inorganic fertilizer is greatly affected by agricultural policies. Policies governing fertilizer use should be examined, for example, to reduce overall quantities of the fertilizer used, and to replace conventional fertilizer with alternative biofertilizerbio fertilizer technologies.

Changes in fertilizer use policies may help to enhance groundwater quality, but alone they would not be enough. Conservation / improvement of groundwater reserves / levels and restoration of groundwater quality will require significant changes in several other policies (see sector paper on groundwater resources). A continuous groundwater monitoring programme is required to document current status of groundwater resources and to monitor future changes in their quality and quantity.

MAF and EAD will have to continue to cooperate to insure proper management of fertilizers in Abu Dhabi Emirate.

3.3 Air Emissions

3.3.1 Definition

Air emissions generally can be categorized as point sources (from a single known source, *e.g.* stack), line sources (*e.g.* busy highway), or diffuse area sources (such as from petrol station and chemical storage area). The nature of emissions can be controlled (*e.g.* from a stack after gas cleaning operations) or uncontrolled (*i.e.* fugitive emissions).

Controlled emissions are usually generated from point sources (*e.g.* stacks) and are a consequence of routine operations. Both the quantity and nature of emissions are relatively easy to measure. Thus they can be regulated and controlled.

Uncontrolled (Fugitive) emissions can include

- Downward migration of pollutants
- Windblown dusts or solid matter carried on the wheels of vehicles
- Leaks from equipment for storage or transportation of materials.

Such emissions may occur from sites of industrial processes, transport, storage or collection of raw material or final product. By definition, fugitive emissions are very difficult to quantify. Losses must be estimated by indirect means, such as mass balances, or by comparing predictions with actual measurements of estimated and projected emission concentrations of pollutants in surrounding air, water or land. Attempts are made to limit these emissions with the use of water sprays and sweeping equipment within the perimeter of works' premises and by covering storage areas

Uncontrolled emissions could also occur in the event of an incident at a site.

3.3.2 History

Monitoring of ambient air quality has become an increasingly important function of air pollution control agencies in this region, through stations established by Abu Dhabi Municipality starting 1995, ADWEA, and more recently through a comprehensive air quality project being implemented by EAD.

It is normally not possible to measure all air pollutants present in the atmosphere, and hence some indicators should be chosen to represent a set of parameters selected to reflect the air quality status. Indicators should enable the estimation of trends and development, and should represent the basis for evaluating human and environmental impact. Furthermore, they should be relevant for decision making and they should be sensitive for environmental warning systems.

The indicator should represent the “pressure” on the environment and include both background indicators and stress indicators. So-called response indicators can be selected to reflect the society's awareness or response to its surroundings.

Abu Dhabi ambient air quality monitoring objectives revolve around the following concepts:

- To judge compliance with and/or progress made towards meeting ambient air quality standards, i.e. to determine whether the air is indeed safe to breathe.
- To activate emergency control procedures that prevent or alleviate air pollution episodes.
- To observe pollution trend throughout a region, including non-urban areas.
- To provide a data base for research evaluation of effects; urban, land-use, and transportation planning; development and evaluation of abatement strategies; and development and validation of diffusion models.

Over the years, several efforts were attempted to adopt suitable air quality criteria for the protection of human health. In 1996, Abu Dhabi Municipality listed in the Ambient Air Quality Annual Report (ADM, 1997) a table including USA EPA Standards, EC Guidelines, WHO Guidelines, ADNOC Guidelines and proposed Ambient Air Quality Guidelines for Abu Dhabi Municipality **(Table 3.3.2-A)**.

The proposed Ambient Air Quality Guidelines for Abu Dhabi Municipality were updated in 1997 and are presented in **Table (3.3.2-B)**. These Air Quality Guidelines were referred to in the Annual Reports from 1997 to 2002.

Pollutant	Averaging Period	USA EPA Standards		EC Guidelines	WHO Guidelines	ADNOC Guidelines	AD Proposed Guidelines	
		µg/m³	Ppb *	µg/m³	µg/m³	µg/m³	µg/m³	Ppb *
NO_2	1-hour			200	400	400	**400**	**212**
	24-hour				150		**150**	**80**
	annual	100	50					
CO	1-hour	40,000	35,000		30,000	30,000	**30,000**	**26,100**
	8-hour	10,000	9,000		10,000		**10,000**	**8,700**
SO_2	1-hour				350	350	**350**	**133**
	24-hour	365	140	100-150	125	125	**125**	**47**
	annual	80	30	40-60	50			
O_3	1-hour	235	120		150-200	200	**200**	**102**
	8-hour				100-120			
NMHC	3-hour (6-9 a.m.)	160	240				**160**	**240**
PM_{10}	24-hour	150					**150**	
	annual	50						
H_2S	30-min.							
	24-hour				150		**150**	**103**

Table 3.3.2A: Initially proposed Abu Dhabi air quality criteria for the protection of human health

Table promulgated by ADM (1997).

* Use 25OC and 760 mmHg to convert the microgram per cubic meter to ppb.

Pollutant	Averaging Period	A/D Proposed Guidelines	
		µg/m3	Ppb*
NO_2	1-hour	200	110
	Annual	40-50	21-26
CO	1-hour	30,000	26,100
	8-hour	10,000	8,700
SO_2	1-hour	350	133
	24-hour	125	47
	Annual	50	17
O_3	1-hour	200	102
	8-hour	120	60
NMHC	3-hour (6-9 am)	160	240
PM_{10}	24-hour	150	-
H_2S	24-hour	150	103
Lead	3 month	1.0	-

Table 3.3.2B: Updated Abu Dhabi Proposed Guidelines, valid from 1997 to 2002.

Air Polluting Parameter	Average Time		Maximum Allowable Concentration in the Ambient Air (µg/m3)
Sulfur Dioxide (SO_2)	1	Hour	350
	24	Hour	150
	1	Year	60
Carbon Monoxide (CO)	1	Hour	30,000
	8	Hour	10,000
Nitrogen Dioxide (NO_2)	1	Hour	400
	24	Hour	150
Ozone (O_3)	1	Hour	200
	8	Hour	120
Total Suspended particulates (TSP)	24	Hour	230
	1	Year	90
Particulate Matter less than ten (10) Microns in Aero-dynamic Diameter PM_{10}	24	Hour	70
Lead (Pb)	1	Year	1

Table 3.3.2C: Recommended Ambient Air Quality Standards for Abu Dhabi Emirate

Table (3.3.2-C) presents the currently proposed Ambient Air Quality Standards for the Emirate of Abu Dhabi.

Proper assessment and control of air pollution also requires the measurement of emissions from pollution sources, either directly or indirectly. Limits for emissions from different stationary sources are contained in a proposed federal environmental byelaw on protection of air quality.

Emissions from different sources in Abu Dhabi Emirate are identified in the next three subsections, followed by a subsection presenting results of air quality modelling, compared sometimes to ambient measurements. The last three subsections address current management actions, issues and implications, and future actions. These subsections almost exclusively rely on data and interpretations contained in reports produced by the Abu Dhabi-wide Air Quality Monitoring and Management Project that is being implemented by EAD in cooperation with other concerned agencies (Guerreiro & Nour, 2004; Bohler et al., 2004; Bohler & Gamal, 2005; Bohler et al., 2005; Guerreiro, 2005; all op. cit. Qawasmeh, 2005).

3.3.3 Stationary Sources

Stationary sources in Abu Dhabi Emirate include the following main sources:

- Power plants
- Oil & Gas industries
- Small industries
- Medical Waste incinerators

Each is discussed separately below.

Power and Desalination Plants

Table 3.3.3-A lists design information about 12 of 13 operating power and desalination plants in the Emirate of Abu Dhabi, as collected during a survey commissioned by EAD. The 12 power plants listed are located at Al-Taweelah (4), Abu Dhabi City (near Mina Zayed, 1), Umm Al Nar (3), Bani Yas (1), Al-Ain City (1), Al Mirfa (1), and Madinat Zayed (1). A large power and desalination plant at Jebel Dhana, near Ruwais (the Shuweihat Power Plant) was not covered by the survey and is not included in the table. All plants are operated by private companies.

The existing plants use a variety of component units (*e.g.* gas turbines, steam turbines, multi stage flash distillation units) to produce electric power and desalinated water **(Table 3.3.3-A)**. Most produce both power and water, whereas some produce either power or water. Most of the production capacity is now concentrated at Taweelah and Umm Al-Nar. The Taweelah complex is located approximately 50km to the north east of the City of Abu Dhabi, 10km off the Abu Dhabi-Dubai highway, and approximately half way between the cities of Abu Dhabi and Dubai. Umm Al Nar (UAN) complex is located on the UAN Island some 20 km east of Abu Dhabi city. It is one of the largest in the UAE, and is the largest producer of potable water in Abu Dhabi Emirate. However, desalination units at UAN-East and UAN-West are planned to be decommissioned to be replaced with new plants to the west of the Island.

Al-Ain power plant generates electricity at present by using both gas turbines and diesel generators, whereas all other power and desalination plants use natural gas as primary fuel for routine operation. However, plants at Taweelah A1, A2 and B are also equipped for using diesel, fuel oil or crude oil as secondary (back up) fuel. These liquid fuels, at present, have a sulphur content of 0.25-0.57% by weight.

Table 3.3.3A: Power and Desalination Plants in Abu Dhabi Emirate

S. No.	Plant (Use*)	Operator**	Component Units ***								Production Capacity			
											Power (MW)		Desalinated Water (MGPD)	
			B	DG	GT	ST	HRSG	MSF	MED	AB	Per Unit	Total	Per Unit	Total
1	Taweelah A1	TTE O&M			8	3	8	4	14	3	96 - 203	1432	3.77 - 8	85
2	Taweelah A2	ECMS			3	2	3	4			-	-	12.65	50.6
3	Taweelah B	TAPCO	6			6		6			123 - 146	800	12	72
4	Taweelah B Extension	TAPCO			2	1	2	3			96.8 - 143	337	7.7	23.1
5	Al-Ain (P)	BPC		8	16						6 - 29	428	N/A	N/A
6	Abu Dhabi	BPC			19	6		4			10 - 30	518	3.75	15
7	Al-Mirfa	MPC			4			6			45	180	-	38.4
8	Madinat Zayed (P)	MPC			5						22	110	N/A	N/A
9	Umm Al-Nar (UAN)-East	APC			4			-		6	60 - 65	250	-	41.7
10	UAN-West	APC	10			10		-			60 - 150	830	-	60.2
11	UAN-B (D)	APC						5		5	N/A	N/A	-	62.5
12	Bani Yas (P)	APC			4						26	104	N/A	N/A

* For power and desalination, unless otherwise noted; P=Power only; D= Desalination only.

** Companies: **APC** = Arabian Power Company; **BPC** = Baynunah Power Company; **ECMC** = Emirates CMS Power Company; **MPC** = Mirfa Power Company; **TAPCO** = Taweelah Asia Power Company; **TTE O&M** = Total Tractebel Emirates O&M Company

*** Components: **AB** = Auxiliary Boiler; **B** = Boiler; **DG** = Diesel Generator; **GT** = Gas Turbine; **HRSG** = Heat Recovery Steam Generator; **MED** = Multi Effect Desalination Unit; **MSF** = Multi Stage Flash Desalination unit; **ST** = Steam Turbine

N/A = Not applicable. - = Data not available.

Table 3.3.3A: Power and Desalination Plants in Abu Dhabi Emirate

Table (3.3.3-B) lists major emission sources (*i.e.* stacks) associated with gas turbines and boilers at each plant. The table provides the number of stacks associated with each plant, and their heights and diameters. It also provides the average monthly consumption of natural gas and its associated heat input.

Dry, low NOx burners are installed at gas turbines of Taweelah A1, A2 and B plants, to control the emission while running on gas fuel. In addition to this, water injection is provided at Taweelah A1 and B for controlling emission in case of machine running on liquid fuel. Also gas burner nozzles and oil nozzles are adjusted at these three plants to limit the emission values to within the specified values at varying loads. However, there are no emission control devices at Al-Ain power plant, and no indication in the data source reports of the presence of such controls in the other plants.

S. No.	Plant	Stacks			Primary Fuel (Natural Gas)*	
		No.	Height (m)	Diameter (m)	Average Monthly Consumption (mmscf)	Average Monthly Heat Input (mmBtu)
1	Taweelah A1	14	50.7-55	2.1-5.3	-	-
2	Taweelah A2	6	40-55	18-20	4062	4242071
3	Taweelah B	6	25.5	3.4	5053	5277976
4	Taweelah B Extension	4	3955	5.33	766	800148
5	Al-Ain	24	10.6-22	1.21-4.29	698	728661
6	Abu Dhabi	25	10.75-30	1.62-3.2	1761	1839857
7	Al-Mirfa	12	60	-	1310	1365926
8	Madinat Zayed	5	13	-	339	345426
9	Umm Al-Nar (UAN)-East	10	30	1.55-4.75	3058	3194494
10	UANWest	10	5060	2.73.8	8247	8613534
11	UAN-B	5	50	2.7	-	-
12	Bani Yas	-	-	-	133	139143

Table 3.3.3B: Emission Related Features of Power and Desalination Plants in Abu Dhabi Emirate

Units: mmscf = Million standard cubic feet.

mmBtu =Million British thermal units.

- = Data not available.

Based on the average fuel gas consumption provided, emission data were established using the EPA's AP-42 Methodology. The emission contribution from each power plant for various pollutants is presented in table (3.3.3-CD), and the emission contribution of the power sector overall is given in table (3.3.3-D).

Power Company	Emission Rate, Tonnes/year							
	CO_2	CO	NO_x	N_2O	SO_x	CH_4	VOC	PM
Al Taweelah A1	4299.7	265.355	5610.05	78.84	22.155	179.215	100.375	258.42
Al Taweelah A2	3094.835	189.8	4035.805	58.4	15.95	129.21	72.27	185.785
Taweelah B Plant	3844070	2639.315	5965.56	70.81	19.856	70.81	173.375	237.615
Taweelah B Extension Plant	583.27	36.135	761.39	10.585	2.993	24.455	13.505	35.04
Al Ain power Station	532.535	36.062	693.135	9.7455	2.7375	22.156	12.41	31.755
Abu Dhabi power Station	1341.375	31.317	1750.175	24.455	6.8985	55.845	31.317	80.3
Al Mirfa, P & D plant	994829.4	682.55	1543.95	18.25	5.11	18.25	44.895	61.32
Al Mirfa Madinat Zayed Power Station	251.52	15.695	328.135	4.745	1.314	83.475	5.84	328.135
Umm Al Na, East Station	2327024.65	1598.7	3611.31	43.8	12.045	43.8	105.12	143.81
Umm Al Nar West	6273135	4306.635	9735.28	116.8	32.485	116.8	282.875	387.63
Umm Al Nar Station-Baniyas	101.47	6.27	132.495	1.862	0.511	1.862	2.37	6.205
Umm Al Nar Station-B	-	-	-	-	-	-	-	-

Table 3.3.3C: Emission Contribution of Power Sector

	Emission Rate, Tonnes/year							
	CO2	CO	NOX	N2O	SOX	CH4	VOC	PM
Total emission from power sector	13449263.8	9807.834	34167.28	438.2925	122.055	715.898	844.352	1756.015

Table 3.3.3D: Total Emission Contribution of the Power Sector.

The above tables show that the major emission contribution in the Abu Dhabi Emirate from the power sector is from Al-Taweelah and UAN areas, which is further illustrated in figure (3.3.3-A).

In addition, stack measurements were performed for several of the plants (Tables 3.3.3-E, F).

Figure 3.3.3A: Percentage of Air Emission Contribution from Power Sector

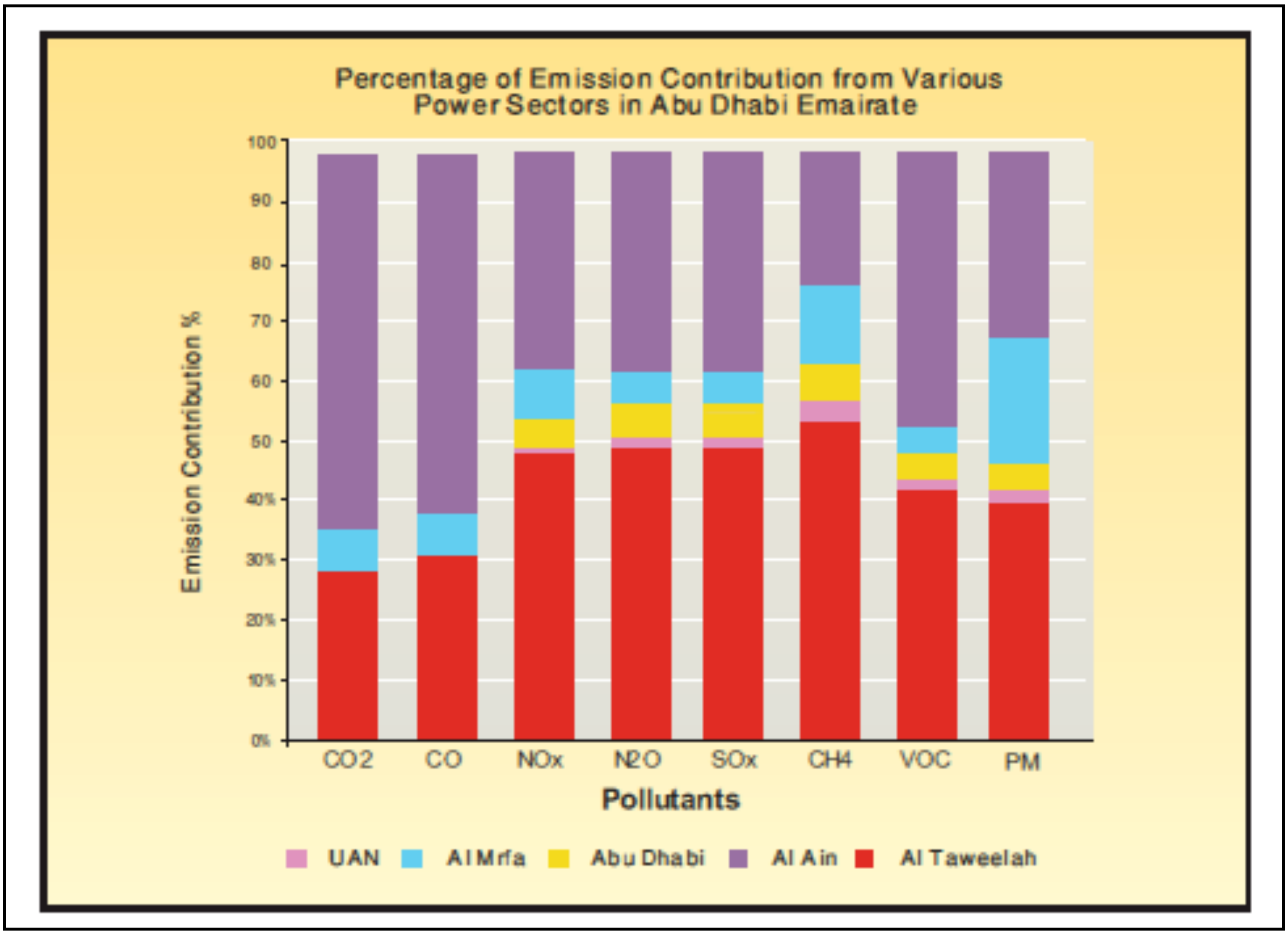


Table 3.3.3E: Results of selected stack measurements at power plants in Tawelah and Al-Ain

Table 3.3.3E: Results of selected stacks measurements at Power Plants in Taweelah and Al-Ain.

Area	Taweelah				Al-Ain		
Name	Gulf total Tractable Power Co.	Gulf total Tractable Power Co.	Gulf total Tractable Power Co.	Emirates CMS Power Co.	Baynunah Power Co.	Baynunah Power Co.	Baynunah Power Co.
Stack ID	HRSG # 12.	HRSG # 14	HRSG # 15.	HRSG # 2	GT-11. (Gas Turbine)	Diesel Engine - 10 (D10)	Diesel Engine-17
Area of Stack (m^2)	22.0707	22.0707	22.0707	31.15	9.6223	1.144	2.54
Stack Height (m)	55	55	55	55	14.85	16.35	21.98
Stack Gas Temperature (c)	169	171	164	N/A	500	240	284
Stack Gas Velocity (m/sec)	N/A	N/A	N/A	18	31	28	25
Volumetric Flow Rate (Nm^3/hr)	N/A	N/A	N/A	N/A	N/A	1232	3670
Sulphur dioxide - (SO_2) (mg/Nm^3)	9	9	2	7	7	182	115
Nitric Oxide - (NO) (mg/Nm^3)	7	13	14	9	89	650	1082
Nitrogen dioxide - (NO_2) (mg/Nm^3)	5	5	6	< 1	< 1	68	145
Oxides of Nitrogen - (NO_X) mg/Nm^3	12	18	20	9	89	718	1227
Carbon monoxide - (CO) (mg/Nm^3)	23	13	11	9	34	108	72
Oxygen - (O_2) %	14	13.1	13.9	14.1	17.4	16	15.3
Carbon dioxide - (CO_2) %	3.9	4.4	3.9	3.9	2	3.8	4.2
Particulate (mg/Nm^3)	N/A	N/A	N/A	N/A	N/A	19	21

N/A = Not available.

Source: Bohler & Gamal (2005)

Table 3.3.3F: Results of selected stacks measurements at Al-Mirfa Power Company

Table 3.3.3 F: Results of selected stacks measurements at Al-Mirfa Power Company (AMPC)

Name	AMPC	AMPC	AMPC AMPC	AMPC	AMPC	AMPC	AMPC	AMPC	AMPC	AMPC
Stack ID	WHRB-1	WHRB-4	Aux. Boiler-1	Aux. Boiler-2	Aux. Boiler-33	Aux. Boiler-43	EGT-2	SS-1	SS-2	KANIS
Area of Stack (m^2)	13.85	13.85	5.765	5.765	7.065	7.065	4	8.41	8.41	10.5
Stack Gas Temperature (c)	157	157	147	147	148	148	565	93	93	540
Stack Gas Velocity (m/sec)	17.3	17.3	14.4	14.4	8.7	8.7	71.77	12.43	12.43	22.1
Volumetric Flow Rate (Nm^3/hr)	862560	862560	299160	299160	221760	221760	1033560	376200	376200	835560
Sulphur dioxide - (SO_2) (ug/Nm^3)	<1000	<1000	<1000	<1000	<1000	<1000	<1000	13000	7900	5200
Nitric Oxide - (NO) (ug/Nm^3)	31000	238000	74000	44000	83000	81000	118000	148000	157000	70000
Nitrogen dioxide - (NO_2) (ug/Nm^3)	6400	15000	1500	1700	2100	1500	<1000	10000	9800	<1000
Carbon monoxide - (CO) (ug/Nm^3)	<1000	<1000	44000	5500	<1000	<1000	4900	4900	1700	1100
Oxygen - (O_2) %	18	17	10.2	14	10.3	9.3	18	17	18	19
Carbon dioxide - (CO_2) %	1.7	2.9	6	4	5.9	6.5	1.9	2	1.9	1.1
Particulate (mg/Nm^3)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

N/A = Not available.

Source: Bohler & Gamal (2005)

Oil & Gas Industries

The majority of air emission sources from ADNOC and its group of companies are generated from exploration and production, refining, gas processing, and petrochemicals industry performed by eleven (11) main air polluting companies:

- Abu Dhabi Company for Onshore Oil Operations (ADCO)
- Abu Dhabi Gas Liquefaction Limited (ADGAS)
- Abu Dhabi Oil Company (ADOC)
- Abu Dhabi Marine Operating Company (ADMAOPCO)
- Abu Dhabi Polymers Company (BOROUGE)
- Bunduq Limited Company (BUNDUQ)
- Ruwais Fertilizer Industries (FERTIL)
- Abu Dhabi Gas Industries Limited (GASCO)
- Abu Dhabi Oil Refining Company (TAKREER)
- Total Abu Al Bukhoosh (TOTAL-ABK)
- Zakum Development Company (ZADCO)

Table (3.3.3-G) lists the major operations of these companies and the number of significant emission sources associated with them. Natural and associated gas from offshore oil operations is processed by Abu Dhabi Gas Liquefaction Limited (ADGAS), whereas that from onshore oil operations is processed by Abu Dhabi Gas Industries Limited (GASCO). Finished products of TAKREER facilities include LPG, unleaded gasoline, kerosene, gas oil and naphtha.

Minor contributions to air pollution, when compared with the previous activities, are produced from ADNOC support services and maritime transportation activities that are performed by seven minor air-polluting companies (see **Table 3.3.3-H**):

- Abu Dhabi National Tanker Company (ADNATCO)
- Abu Dhabi National Oil Company For Distribution (ADNOC-DISTRIBUTION)
- ESNAAD
- Abu Dhabi Petroleum Ports Operating Company (IRSHAD)
- National Drilling Company (NDC)
- National Gas Shipping Company (NGSCO)
- National Petroleum Construction Company (NPCC)

At present, the NPCC is not part of ADNOC, after being placed under direct supervision of Abu Dhabi Executive Council. Nevertheless, it will be treated in this paper together with ADNOC Group companies, to facilitate interpretation of available interrelated data sets.

Existing ADNOC (Oil & Gas) data (collected in 1997) show that there are more than eight hundred (800) air emission sources within ADNOC main air polluting companies (Table 3.3.3-G), whereas sources within ADNOC minor contributors (Table 3.3.3-H) are still to be identified.. Table (3.3.3-I) lists representative emission sources within the eleven main air polluting companies. But the amount of available physical parameters and emission data per source is low, especially for the two major companies, ADCO and ZADCO.

Operating Area	Company	Field / Location	Key Processes	No. of Emission Sources
Onshore / Coastal Fields	ADCO	Al-Dabbi'ya	• Oil and gas production • Storage and loading, at Jebel Dhana	11
		Asab,		29
		Bab		12
		Bu Hasa		32
		Jarn Yahphour		3
		Jebel Dhana		11
		Rumaitha		5
		Sahil		12
		Shah		7
Offshore Fields	ADOC	Mubbaraz Island, West Mubbaraz, Mubbaraz Field	• Oil and gas production. • Processing and storage at Mubbaraz Island	31
	ADMA--OPCO	Umm Shaif	• Oil and gas production • Processing and storage at Das Island	26
		Zakum-West		18
		Zakum Central		14
	Bunduq	El-Bunduq	• Oil and gas production. • Processing and storage at Das Island	33
	Total-ABK	Abu Al-Bukhoosh	• Oil and gas production	N/A
	ZADCO	Upper Zakum	• Oil and gas production. • Processing and storage at Zirku Island	87
		Umm Al-Dalkh		71
		Satah & Arzanah		37
Crude Oil Processing	ZADCO	Zirku Island	Processing of crude oil; Part of gas sent to Das Island	21
	ADCO	Jebel Dhana	Oil storage and loading activities Gas oil separation plant (GOSP)	11
		Bu Hasa		N/A
	ADMA--OPCO	Das Island	Gas separation, H2S removal, dehydration, storage, exporting	44
Gas Processing	ADGAS	Das Island	Gas plant	N/A
	GASCO	Asab	Gas plant	18
		Habshan	Gas plant	43
		Bab	Gas plants	15
		Bu Hasa	Gas plant	31
		Ruwais	Gas plant, Fractionation plant, Storage and loading facilities	49
Petro-chemicals and Refining	Takreer	Umm Al-Nar	Refining of crude oil, Production of liquid sulphur (sent to Ruwais)	20
	Borouge Fertil	Ruwais	Refining of crude oil, Production of granulated sulphur	43
		Ruwais	Ethane-based ethylene cracker, Polyethylene plant	14
		Ruwais	Conversion of gas into fertilizers (anhydrous ammonia, urea)	15

Table 3.3.3G: ADNOC Main Operations and Number of Associated Emission Sources N/A = Not available.

Company	Main Activities	Potential Emission Sources
ADNATCO	• Transportation of crude oil, gas, and products. • Seven tankers for crude and products, and a molten sulphur carrier. Manages ADNOC bunker supply ships.	From tankers and ships.
ADNOC--DISTRIBUTION	• Marketing and distribution of petroleum products through three major depots (Mussafah, Madinat Zayed, Al-Ain), two small depots (Mina Zayed, Ruwais), and network of filling stations. • Product distribution through pipelines to depots and a fleet of road tankers to filling stations. • Three vessels to transport products to islands. • Some plants (lubricant blending and filling; grease; LPG bottling).	Emissions of VOCs (about 7600 tons/year; 2% of total).
ESNAAD	• Logistical support and fleet management. Production of specialty / drilling chemicals. Has a base in Mussafah.	From chemical production, vessels, jetties
IRSHAD	• Operation of ports, vessels of different types. • Two vessel maintenance workshops (Ruwais, Das Island). Safety and diving services • Maintenance operations. • Oil spill combating.	From workshops, ports, vessels
NDC	• Drilling using rigs (10 offshore, 12 onshore, 6 for water) and mainte- nance operations	From drilling engines
NGSCO	• Operation of own eight LNG carriers, and chartering of others for transport of LNG, LPG and sulphur.	From ships and tankers
NPCC*	• Engineering, procurement and construction (EPC) contractor. Fabrication yard in Mussafah. • Has a marine fleet.	From vessels, fabrication activities

Table 3.3.3H: Main Activities of ADNOC Support Companies.
* Presently not an ADNOC company – see text.

Operating Area	Company	Field / Location	Significant Emission Sources
Onshore / Coastal Fields	ADCO	Al-Dabbi'ya, Asab, Bab, Bu Hasa, Jarn Yahphour, Jebel Dhana, Rumaitha, Sahil, Shah	• Flares • Burn pits • Gas turbines (power production) • Fugitive emissions (especially at Jebel Dhana oil storage and loading terminal)
Offshore Fields	ADMA- OPCO	Umm Shaif, Zakum-West, Zakum Central	• Flares • Glycol dehydraters • Glycol reboiler heaters Turbines • Diesel engines • Fugitive emissions
Crude Oil Processing	ADMA- OPCO	Das Island	• Flares • Gas turbines Storage tanks Steam boilers Heaters, • Fugitive emissions • Gas turbines
Gas Processing	GASCO	Asab	• Regeneration furnaces Burn pits • Flares

Table 3.3.3I: ADNOC Representative Emission Sources

The majority of air emission due to Exploration and Production activities arises from the use of fuel or from controlled flaring and venting, which is necessary for safe operation. Considerable amount of the emissions are hydrocarbons, consisting predominantly of methane. The remaining emissions, principally NO_x, SO_x and CO, are produced during the fuel combustion. CO_2 is not included because its impact is much lower.

In downstream oil activities (*i.e.* Oil Refining and Marketing), the emissions are due both to the losses to the atmosphere of hydrocarbons and to combustion products, which occur in refining process as the chemical composition of the oil is modified to meet the product demand. The environmental emissions from the final part of the oil industry chain, that of distributing and selling the final product to the consumer, are essentially all VOC emissions occurring during transfer of the product.

For CO and NO_x emissions, GASCO have 71% of sources with available data and the highest emissions. GASCO Gas Processing activities seem to be by far the greatest emitter of CO_2, CO, NO_x and SO_x compared with the other companies and considering the available data. TAKREER, ADGAS and ADCO are probably the companies emitting most NO_x after GASCO. ADGAS and ADMA are also major contributors to SOemissions.

Small Industries

Most of the non-oil industries in Abu Dhabi are located in industrial areas in Mussafah, Mafraq and Al-Ain (Section 3.1.5), together with storage facilities of chemicals and radioactive sources (Sections 3.1.7 and 3.1.8). No information on air emissions from stores of chemicals and radioactive sources is available at this stage. **Table (3.3.3-J)** gives information on air emissions and facility details for few industries in Mussafah, and **Table (3.3.3-K)** gives results of stack measurements for few industries in Mussafah, Mafraq and Al-Ain.

Industry (Product)	Air Emission Attributes
Gulf Steel Industries (Deformed steel bars)	• Two stacks (25m high, 40 cm diameter). • Fuel oil consumption 200L/hr/unit (two units). • Stack gas temperature 200250°C.
National Fodder Production (Animal feed)	• One stack (15 m high) attached to a boiler. • Boiler operated 7200hrs/year (intermittent). • Diesel consumption 5000gallons/month.
Abu Dhabi Ship Building (shipbuilding and repair)	• Six diesel based generators for emergency use. • Storage facility for fuel (10000 gallons) and paint (5000 L/day).
Bin Butti Industries (corrugated cartons). Jotun Paints Abu Dhabi (protective, marine & decorative paints).	• Fuel oil consumption 3000 gallons/month; operating 2500 hrs/year. 8 stacks (height 12 m; diameter 65 cm). • Flue gas temperature 250°C, velocity 911 m/s. • Emissions of SO_x (4454mg/NM³), CO (100 ppm) and H_2S (12.5 %). Main source is fume extraction system stack. • Three ducts with height 13.3 m and diameters ranging from 700mm X 700mm to 900mm X 800mm. • Storage facility for xylene and naphtha.
Castle Gate (woodwork).	• One boiler stack (height 8 m, diameter 15 cm).
Giffin Traffiks (galvanization).	• Four diesel burners. • One stack (height 12 m, diameter 0.5 m). Operated continuously (8700hr/year). Three HCL storage tanks.

Table 3.3.3J: Air Emission Attributes of Selected Industries in Mussafah

Table 3.3.3K: Results of selected stacks measurements at Mussafah. Mafraq and Al-Ain Industrial Areas.

Area	Mussafah			Mafraq		Al-Ain
Company	Gulf Steel Co.	Gulf Steel Co.	Technical Metal Industries	Admak Gen. Cont. Co.	Tarmak Ltd.	Al Ain National Juice & Refreshment Co.
Stack ID	Rolling Mill # 1	Rolling Mill # 2	Boiler Stack	Dust Filter Exhaust	Dust Filter Exhaust	Juice Factory
Area of Stack (m^2)	0.1963	0.2641	0.1017	1.3267	0.8655	0.2826
Stack Height (m)	30	30	25	30	12	10
Stack Gas Temperature (°C)	385	310	125	111	109	473
Stack Gas Velocity (m/sec)	14.4	12.9	6.1	9.9	9.2	8.65
Volumetric Flow Rate (Nm^3/hr)	4429	6083	1640	35963	22204	5475
Sulphur dioxide - (SO_2) (mg/Nm^3)	100	883	259	< 1	3	94
Nitric Oxide - (NO) (mg/Nm^3)	63	55	54	49	16	39
Nitrogen dioxide - (NO_2) (mg/Nm^3)	< 1	< 1	< 1	4	< 1	<1
Oxides of Nitrogen - (NO_x) mg/Nm^3	63	55	54	52	16	39
Carbon monoxide - (CO) (mg/Nm^3)	1	682	1	1638	167	38
Oxygen - (O_2) %	19.3	10.9	12.2	14.6	19.5	13.3
Carbon dioxide - (CO_2) %	1.2	7.6	6.5	4.7	1.1	5.7
Particulate (mg/Nm^3)	79	82	17	22	14	402

Table 3.3.3K: Results of selected stacks measurements at Mussafah, Mafraq and Al-Ain Industrial areas

Hospital Incinerators

Abu Dhabi Emirate has incinerators only for medical wastes. A number of hospital incinerators in Greater Abu Dhabi Area are not operating at present (closed between 2000 and 2002) (see Section 3.1.6). Until December 2003, 12 incinerators in major hospitals in Al Ain area were used for incineration of medical wastes **(Table 3.3.3-L)**. Based on the capacity of each incinerator and its work frequency, the quantity of medical waste incinerated by Al Ain Hospitals could be estimated at about 1330.572 tones per year. Also based on the capacity of the incinerator and total burning of waste, the emission rate for the various pollutants could be calculated **(Table 3.3.3-M)** by using the US-EPA – AP-42 Method.

It should be noted, however, that hospital incinerators in Al- Ain area are closed at present except those at Tawam Hospital (used intermittently to incinerate cytotoxic waste) and Al-Ain Central Hospital (still incinerating its wastes). Results of stack measurements at the latter two incinerators are given in **Table (3.3.3-N)**. Waste from all other incinerators is now sent to private companies for treatment using non-incineration methods (Section 3.1.6).

Hospital	Incinerator's Details						
	GPS Location	Height, m	Diameter, cm	Type of fuel	Work days	Amount of fuel	Capacity of incinerator
Al Khazna	N 24 16 98.7 E 55 113 77	10	30	Diesel	Twice a week	N/A	32 kg/hr
Tawam (Al Ain)	N 24 19 625 E 055 64 480	20	40	Diesel	Daily	N/A	2500kg/day
Al Waha	Al Ain	10	30	N/A	Daily	N/A	35kg/hr, 3 hr/day
Al Hai R	N 24 59 021 E 55 74 58.9	20	40	Diesel	Daily	N/A	32kg/hr 1hr/day
Fuqia		20	40	Diesel	Daily	N/A	32kg/hr 1hr/day
Shwaib		20	40	Diesel	Daily	N/A	32kg/hr 1hr/day
Al Wagan		15	40	Diesel	Daily	N/A	32kg/hr
Al kui		15	40	Diesel	Daily	N/A	32kg/hr
Gimi Hospital	Al Ain	20	60	Diesel	Daily	1500 gallon/month	150 kg/hr 5 hr/day
Miziad	N 24 08 560 E 55 83 850	15	40	Diesel	Daily	N/A	35kg/hr 2hr/day
Al Sad	N 24 19 836 E 55 52 499	10	30	Diesel	Daily	500 gallon/month	20 kg/day
Ramah	N 24 17 924 E 55 33 420	10	30	Diesel	Daily	N/A	32kg/hr

Table 3.3.3L: List of incinerators with physical parameters

N/A=Not available.

Table 3.3.3M: Estimated emission rates for incinerators based on quantities incinerated and technology used

Emission Rate for Pollutants Kg/year	Name of Hospital in Al Ain											
	Alkui	Alwajen	Shwaib	Fuqia	Alhair	Alwaha	Tawam (AlAin)	Alkhazna	Rammah	Al Saad	Miziad	Gimi
	Estimated Quantity of Waste Incinerated, tonnes/year											
	11.68	11.68	11.68	11.68	11.68	38.32	912.5	3.072	11.68	7.3	25.55	273.75
	Estimated Emission Rate, kg/year											
NOx	2.079	2.079	2.079	2.079	2.079	6.82	1.624	5.468	2.079	1.299	4.548	4.873
CO	1.723	1.723	1.723	1.723	1.723	5.65	1.346	4.531	1.723	1.077	3.769	4.038
SO2	1.267	1.267	1.267	1.267	1.267	4.158	9.901	3.33	1.267	7.92	2.772	2.97
Total PM	2.727	2.727	2.727	2.727	2.727	8.948	2.131	7.173	2.721	1.705	5.966	6.392
PM 10	2.618	2.618	2.618	2.618	2.618	6.62	1.577	5.308	2.01	1.261	4.359	4.730
PM 2.5	1.718	1.718	1.718	1.718	1.718	5.63	1.342	4.51	1.71	1.07	3.759	4.027
TOC	1.746	1.746	1.746	1.746	1.746	5.729	1.364	4.59	1.746	1.09	3.82	4.093
Total PCBs	2.716	2.716	2.716	2.716	2.716	8.909	2.122	7.14	2.716	1.697	5.94	6.365
*HCL	1.956	1.956	1.956	1.956	1.956	6.419	1.528	5.14	1.956	1.223	4.28	4.58
*HF	8.702	8.702	8.702	8.702	8.702	2.855	6.798	2.289	8.702	5.438	1.90	2.039
*Chorine	6.12	6.12	6.12	6.12	6.12	2.012	4.79	1.61	6.132	3.832	1.34	1.437
Hydrogen Bromide	2.529	2.529	2.529	2.529	2.529	8.296	1.976	6.65	2.529	1.58	5.53	5.927

Note: * = Hazardous air pollutants as defined by section 112 (b) of USA Clean Air Act.

Assumptions: Type of Incinerators considered as controlled air incinerators
Uncontrolled emission categories

Table 3.3.3M: Estimated emission rates for incinerators

Stack	Incinerator Stack	Incinerator Stack
Area of Stack (m2) Stack Height (m)	0.41 26 30	0.2289 10
Stack Gas Temperature (c) Stack Gas Velocity (m/sec)	445 15.8	827.5 17.2
Volumetric Flow Rate (Nm3/hr)	9560	3787
Sulphur dioxide - (SO2) (mg/Nm3)	56	58
Nitric Oxide - (NO) (mg/Nm3)	42	79
Nitrogen dioxide(NO2) (mg/Nm3)	< 1	< 1
Oxides of Nitrogen - (NOx) mg/Nm3	42	79
Carbon monoxide - (CO) (mg/Nm3)	64	73
Oxygen (O2) %	18	12.9
Carbon dioxide - (CO2) %	2.1	6.01
Particulate (mg/Nm3)	277	388

Table 3.3.3N: Results of selected stacks measurements Al Ain Hospital Incinerators.

3.3.4 Area sources

No information is available at this stage on the area sources including the following:

- Open burning/landfill sites
- Fuel storage depots;
- Petrol filling stations.

3.3.5 Line Sources

Technical Memorandum 2.2.1 of the Abu Dhabi Master Transportation Plan, prepared for the Traffic Control Centre (TCC), contains traffic flow data for 1999 at 155 measuring points, located at 78 of the signalised intersections on the island **(Figure 3.3.5-A)**. Each measuring point has two detectors, counting the traffic on two lanes, but almost all of the measuring points have either three or four lanes of travel, so significant traffic volumes were missed by the study. Nevertheless, the data provides the ability to track changes in traffic volumes through various time periods, including hourly (for weekdays only) and monthly/seasonal changes.

Figure 3.3.5A : Locations of the 155 measuring points in the Traffic Control Centre traffic monitoring programme.

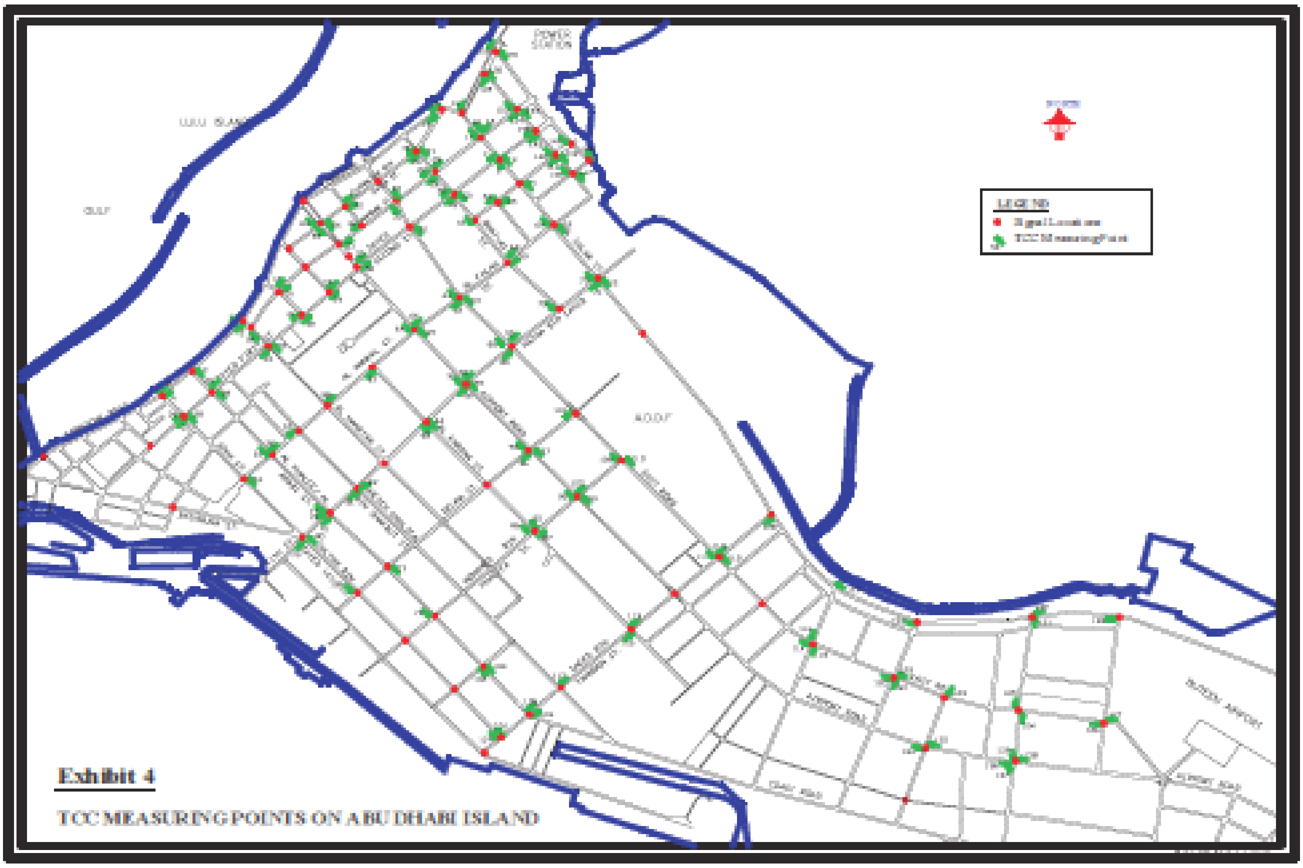


Figure (3.3.5-B) presents the overall magnitude of weekday traffic for the twelve months of 1999, based on data collected for 38 measuring points where reliable counts are available for all twelve months of that year. This figure shows that the observed traffic volumes, normalized to the average weekday volume, do not vary greatly from month to month. Ten of the months fall within a narrow range, between 99 percent and 106 percent of the average monthly traffic volume. Only the summer months of July and August fall outside of this range.

The twelve months data also show that there are three distinct distribution patterns of traffic volumes throughout the day during different periods of the year. These can be defined as the normal pattern, the summer pattern, and the Ramadan pattern (Figure 3.3.5-C).

Another Technical Memorandum of the Abu Dhabi Master Transportation Plan contained data necessary for modelling impacts of traffic air emissions, including:

- Screenline and cordon counts
- Intersection/roundabout turning movement counts
- Vehicle classification counts
- Vehicle occupancy counts

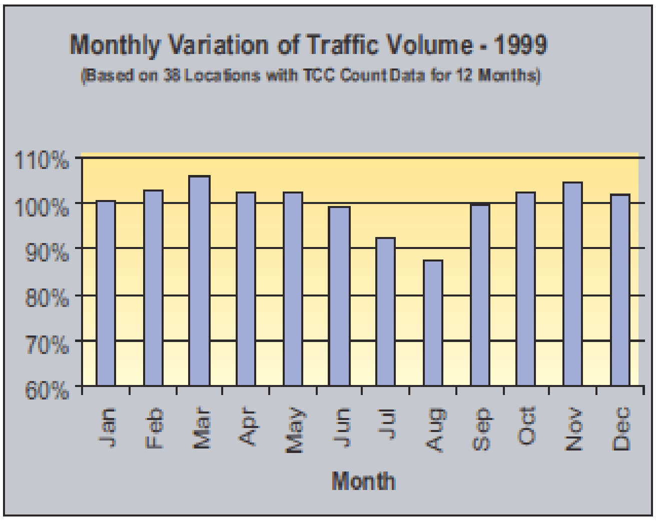


Figure 3.3.5B: Monthly variation of traffic volume based on 38 locations with TCC count data for the 12 months of 1999.

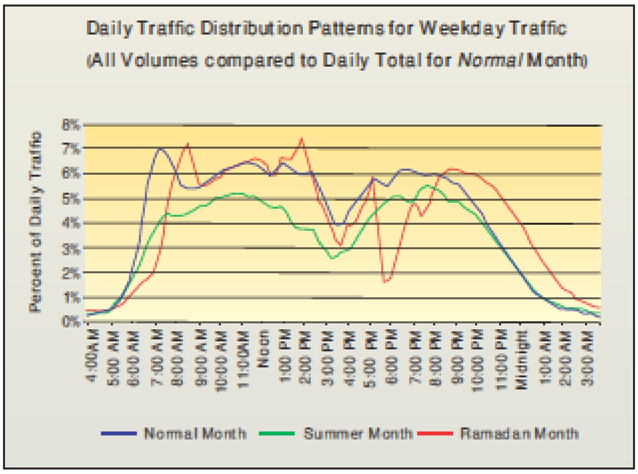


Figure 3.3.5C: Daily Traffic Distribution Patterns for Weekday Traffic.

3.3.6 Modelled Air Quality

Computer modelling was used to assess impacts of emissions from stacks and traffic on ambient air quality in different areas. Impacts of each source could be modeled separately, thus allowing the identification of its contribution to the observed pattern. The simulation model used could produce hourly averages and maxima, 6-months averages and maxima, and yearly averages and maxima.

Abu Dhabi City and Surroundings

The air pollution dispersion calculations show that inside the Abu Dhabi city, due to emission conditions and prevailing wind, traffic is the main contributor to impact of nitrogen oxides. The proposed one-hour air quality guideline for NO_2 (200 µg/m3) is exceeded inside Abu Dhabi city with the emissions from traffic alone (Figure 3.3.6-A). However, point sources like power plants will give increased impact downwind in prevailing wind directions. Their contribution, added to the contribution from traffic, can lead to exceedance of the proposed air Quality Guidelines in areas outside the city centre (**Figure 3.3.3-B**) where these guidelines were not exceeded with the contribution from traffic alone. The present Abu Dhabi one-hour air quality guideline for NO_2 (400 µg/m3) is not exceeded.

The proposed air quality guideline for annual average NO2 is 50µg/m3, and results of modelling show that it is not exceeded in Abu Dhabi city with the contribution from the traffic emissions alone. Nevertheless, when considering the emissions from traffic and from the industry in Umm Al Nar, the same guideline is exceeded on an impact area south- southeast from the Umm Al Nar industrial area, but not in the centre of Abu Dhabi city.

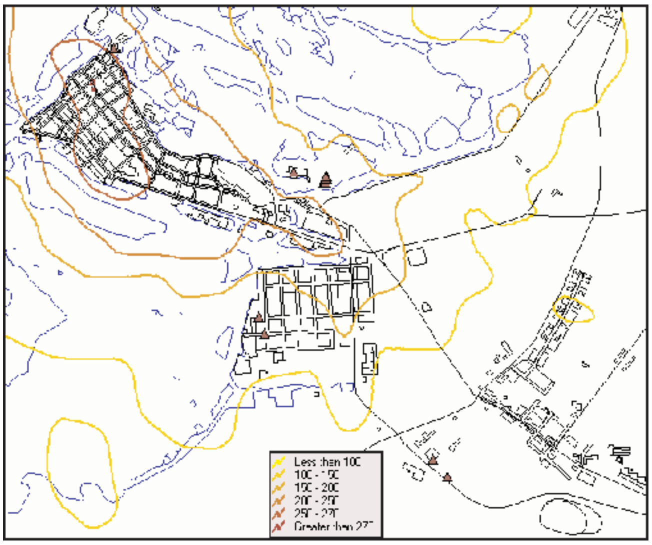


Figure 3.3.6A: One-hour average NO_2 concentrations (μg/m^3) from traffic emissions in Abu Dhabi city.

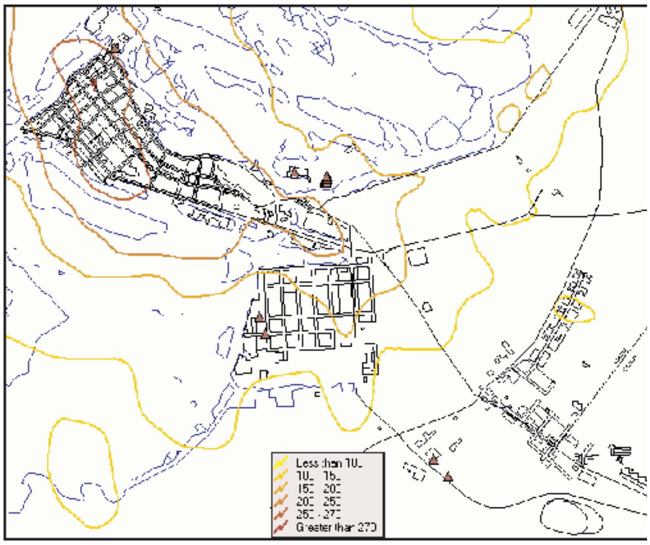


Figure 3.3.6B: Maximum one hour average NO_2 concentrations (μg/m^3) from traffic and industrial emissions in Abu Dhabi city.

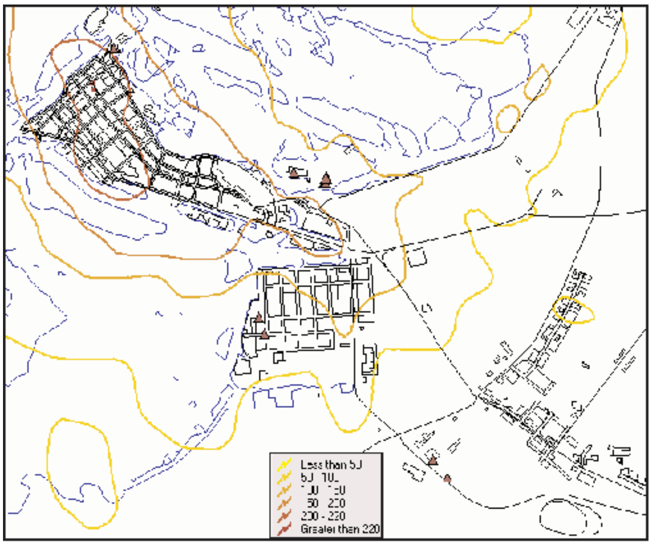


Figure 3.3.6C: Maximum one hour average SO_2 concentrations (μg/m^3) from traffic and industrial emissions in Abu Dhabi city.

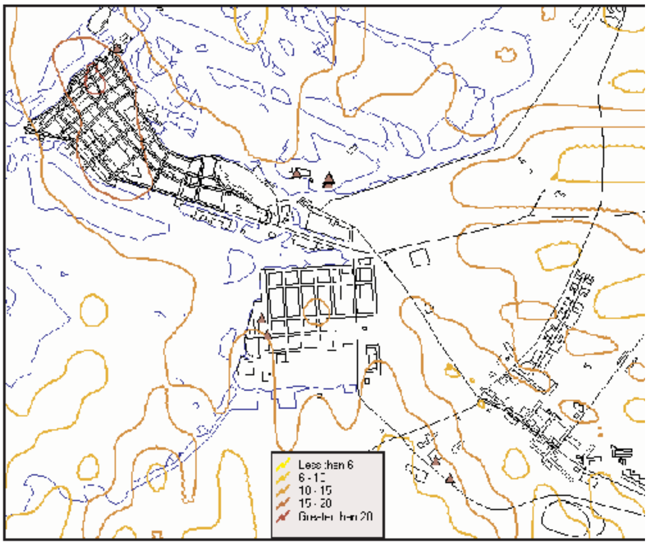


Figure 3.3.6D: 6-month average SO_2 concentrations (μg/m^3) from traffic and industrial emissions in Abu Dhabi city.

The maximum 1-hour SO_2-concentrations in Abu Dhabi city and surroundings does not exceed the one-hour air quality guideline for SO_2 (350 μg/m^3), but it reaches a maximum of 250 μg/m^3 in Mussafah industrial area (**Figure 3.3.6-C**). In the centre of Abu Dhabi city the maximum 1-hour SO_2-concentrations are between 100 and 125 μg/m^3.

The 6-month average SO_2-concentrations in Abu Dhabi city and surroundings does not exceed the one-year air quality guideline for SO_2 (60 μg/m^3). The 6-month average SO_2 -concentrations reaches its maximum in Mussafah with 22 μg/m^3 and in Al Mafraq with 20 μg/m^3 (Figure 3.3.6-D). In the centre of Abu Dhabi city are between 9 and 12 μg/m^3

Air quality in Mussafah was measured by a mobile laboratory over a 10-day period. The measurements (Table 3.3.6-A) gave no exceedences of the UAE ambient air quality guidelines. However, for PM_{10}, the mean value for the 10 days period was close to the daily average air quality guideline. The concentration level of SO_2 was on average among the highest measured and the H_2S measurements gave the highest values measured at all locations.

Parameter	Values (µg/m³)		
	Mean	Minimum	Maximum
NO_x	83.7	4.5	446.4
NO	20.2	0	120.9
NO_2	52.8	3.3	120.2
SO_2	14.7	1.9	67.2
H_2S	9.7	2.6	24.3
CO	0.6	0.1	1.5
O_3	41.4	0	126.3
PM_{10}	135.0	28.0	572.0

Table 3.3.6A: Ambient Air Quality in Mussafah

Habshan and Medinat Zayed

Modelling showed that the highest 6-month average of NO_2 concentrations was 17 µg/m³ about 1-2 km southeast from Habshan Plant. The calculated maximum 1-hour NO_2 concentration was 150 µg/m³ and occurred about 1-2 km southwest from Habshan Plant. In Medinat Zayed the 1-hour maximum NO_2 concentrations vary between 30 and 60 µg/m³. Neither the Abu Dhabi nor the proposed air quality guidelines for NO_2 are exceeded in Habshan or Medinat Zayed.

The 6-month average of SO_2 concentrations reaches its highest value about 1-2 km southeast from Habshan Plant, with around 200 µg/m3 SO_2. The Abu Dhabi air quality guideline for 1-year average SO_2 (60 µg/m3) and it is exceeded in an area of about 20 km2 around the Habshan Plant.

The calculated maximum 1-hour SO_2 concentration 1-2 km around the Habshan Plant varied between 1800 and 2200 µg/m³. The Abu Dhabi air quality guideline for 1-hour SO_2 concentration (350 µg/m³) is exceeded over most of the modelled area, including most of Medinat Zayed town, where the 1-hour maximum SO_2 concentrations vary between 280 and 930 µg/m³.

On average, the contribution of the industrial sources to the NO_2 concentration levels in Medinat Zayed is very small (between 2 and 4 µg/m³), but it is very significant for the 1- hour maximum SO_2 concentrations, which guideline is exceeded over a large area around Habshan.

Ruwais

Ruwais area includes Ruwais Industrial complex, Ruwais housing complex for engineers & employees who are working at the industrial complex and small contractor's camps for subcontractors who are working at Ruwais for temporary basis. The main emission source at Ruwais is the industrial complex including one refinery, one gas plant and two petrochemical plants, in additions of existing Abu Dhabi / Sila main road.

The 6-month average NO2 concentration reached its highest value about 1 km south from Ruwais NGL Fractionation Plant and about 1 km northwest from Ruwais refinery, with 25 µg/m3 NO2. In Ruwais residential area the average NO2 concentration was about 10 µg/m3, well below the air quality guidelines.

The calculated maximum 1-hour NO2 concentration was 215 µg/m3 and occurred about 1 km south from Ruwais NGL Fractionation Plant and about 1 km northwest from the Ruwais refinery. This is above the proposed one-hour air quality guideline for NO2 (200 µg/m3), but under Abu Dhabi air quality guideline (400 µg/m3). In Ruwais residential area the 1-hour maximum NO2 concentrations varied between 30 and 60 µg/m3.

The 6-month average SO2 concentration reached its maximum about 1-2 km from Ruwais NGL Fraction Plant, with 140 µg/m3 SO2. The Abu Dhabi air quality guideline for 1-year average SO2 960 µg/m3) is exceeded in an area of about 8 km2 around Ruwais NGL Fractionation Plant.

The calculated maximum 1-hour SO2 concentration about 1 km around the industrial sources varied between 400 and 1660 µg/m3. The Abu Dhabi air quality guideline for 1-hour SO2 concentration (350 µg/m3) is exceeded over more than half of the modelled area, including part of the Ruwais residential area. In Ruwais residential area the 1-hour maximum SO2 concentrations varied between 230 and 61 5µg/ m3.

Field measurements using a mobile laboratory (Table 3.3.6-B) gave no exceedences of air quality guidelines for PM10 and the gases except for ozone. However, the overall highest SO2 concentrations were measured at this location due to position downwind of industrial activities. The highest concentrations of sulphur dioxide occurred during winds from around north which clearly indicates the impact from the industrial activities at Ruwais.

Parameter	Values (µg/m³)		
	Mean	Minimum	Maximum
NO_x	28.9	1.7	129.8
NO	4.8	0	35.9
NO_2	21.7	0	83.9
SO_2	17.2	0.7	240.6
H_2S	4.1	0	20.3
CO	0.3	0	1.1
O_3	90.8	2.7	203.1
PM_{10}	132.8	7.0	593.0

Table 3.3.6B: Ambient Air Quality in the Ruwais Area.

Al Ain

The 6-month average of NO_2 concentrations reaches its maximums in the city centre, with 27 µg/m3 NO2. The maximum average concentration close to the power plant for NO_2 is 28 µg/m3. The proposed air quality guideline for annual average NO_2 (50 µg/m3) is not exceeded.

The 1-hour maximum NO_2 concentrations inside the city vary between 100 and 230 µg/m3, which is above the proposed one-hour air quality guideline for NO2 (200 µg/m3) but under the Abu Dhabi guideline (400 µg/m3).

The 6-month averages of SO_2 concentrations reaches its maximum in Al Ain Centrum with 10 µg/m3 SO_2 , well bellow the Abu Dhabi air quality guideline for 1-year average SO_2 (60 µg/m3).

The calculated maximum 1-hour SO_2 concentrations vary between 60 and 104 µg/m3 in the city centre, not exceeding the Abu Dhabi air quality guideline for 1-hour SO_2 concentration (350 µg/m3).

In General

Modelling of ADNOC offshore activities gave high air pollution impacts at Das and Zirku islands and elevated background values of sulphur dioxide onshore (Figure 3.3.6-E). The industrial areas of Habshan, Ruwais, Mussafah and Mafraq all had emissions leading to high impact of sulphur dioxide and dihydrogensulfide. Some other site, e.g. Shah and Sahil, were not investigated.

3.3.7 Current Management Actions

Environment Agency – Abu Dhabi (EAD) as part of its efforts to ensure sustainable balance between economic growth and healthy environment is currently implementing an Emirate wide Air Quality Monitoring and Management Project aiming at protecting the environment for generations to come, especially under the major development the emirate is witnessing in all economical, social and technological aspects.

The project is subdivided into four distinct stages, the first of which constituted baseline data collection and assessment in collaboration with a multi-disciplinary, multi-sectoral technical team representing Abu Dhabi Municipality, Al-Ain Municipality, Abu Dhabi National Oil Company (ADNOC), Abu Dhabi Water and Electricity Agency (ADWEA) and Abu Dhabi Police Department. Based of the said assessment and collected data, a tender document was compiled and a successful bidder was chosen to execute the project.

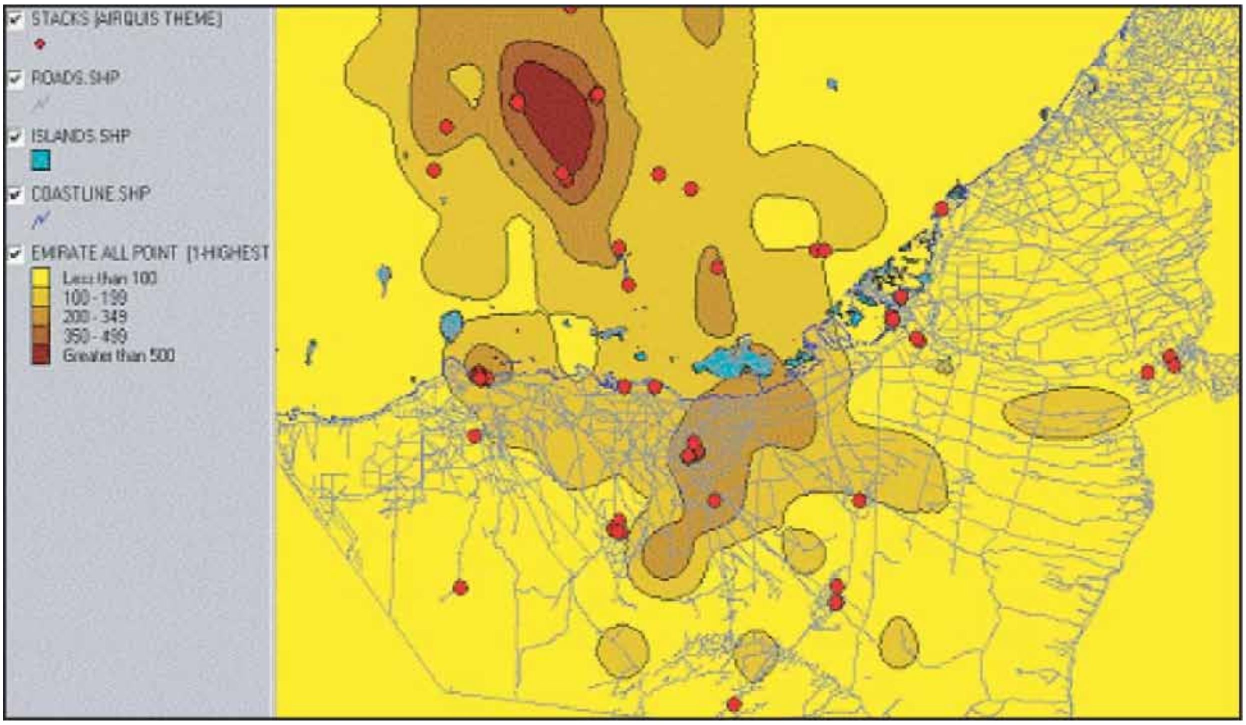


Figure 3.3.6E: Maximum one-hour averaged SO2 concentrations for the emirate of Abu Dhabi from emissions from ADNOC sources.

The recently concluded second stage comprised of analysis of the emissions and dispersion of flue gases from industrial stacks (point and area stationary sources) and the emissions from vehicular traffic (on-road and off-road mobile sources) in the Emirate by using internationally approved air dispersion models. Hot spots were identified. And specifications, optimum number and locations of fixed and mobile Air Quality Monitoring Stations were drawn to effectively and comprehensively monitor the major industrial and residential areas of Abu Dhabi.

The current third stage is comprised of the establishment of the Air Quality Management Network designed in the previous stage through the purchase, construction and operation of a Central Network System, and a fully equipped and functional Air Quality Monitoring System. The Tender of this phase will be awarded towards the end of 2005 and field work initiated in 2006.

The continuous operation and manipulation of the installed state-of-the-art system comprise the fourth and last stage of this project. Experience will be built throughout the previous stages and will continue throughout the life of the project to ensure maximum utilization of this invaluable planning and prediction tool.

Permitting of existing and new industrial projects is yet another management tool through which the Environment Agency imposes certain conditions on the developer to ascertain compliance with established air emission limits and standards. Medium size industries are usually required to perform a Preliminary Environmental Review Study (PER) to take into account the current environmental situation and the immediate impact the proposed project might have on the surrounding environment. Large scale projects (e.g. power plants, urban development projects, etc) are required to establish the environmental baseline (including air) for a period of several months after which they develop Environmental Impact Assessment (EIA) study during which several options are offered and the most environmental - friendly one is chosen. Air quality monitoring stations are usually required to establish a continuous profile of the area before and after project construction and operation to ensure that the instated mitigation measures are adequate to curb the air pollution and to validate the results of air dispersion modelling required to be undertaken through the EIA process. Existing industries are also required to monitor their stack emissions periodically by third party laboratories.

Unleaded gasoline was introduced in the UAE, effective 1 January 2003. ‘UAE Goes Green’ was designed to phase out leaded fuel throughout the UAE. This involved the conversion of 500 filling stations nationwide to unleaded gasoline, the training of transport and service station personnel, and an awareness campaign for 750,000 UAE motorists.

3.3.8 Issues and Implications

Oil and Gas is the major air quality pollution contributor in Abu Dhabi Emirate, in spite of its efforts so far to preserve the environment and minimize ill-effects onto it. The sector has a detailed and vigorous health, safety and environment section and carries out initiatives to reduce emissions. The Abu Dhabi Oil Company (ADOC), for example, has reduced flaring emissions with two major projects, one on zero flaring and the second on sour gas. The Abu Dhabi Polymers Company Limited (Borouge) has implemented modern technology to reduce fugitive emissions, including a leak detection and repair system. Emissions from the Satah H2S flare will be significantly reduced (to 1% of the current) after implementation of the Satah Amine bypass project.

However, the current reading of the air quality surrounding ADNOC operations suggests that a more stringent management of operations must be imposed - possibly through a neutral third party - to better the performance of the sector. In addition, being not yet regulated by the competent environmental authority hinders transparency in imposing environmental regulations and is considered a conflict of interest.

Power and Traffic Sectors are the second and third most air polluting sources but are currently undergoing technological transformation that will reduce the negative impacts on air quality opposed to their socio-economic benefits. For example all power generating plants are obliged to use Natural Gas as the primary fuel for its operations with a clean diesel as backup. Old facilities relying on liquid fuels are currently being decommissioned (e.g. Umm Al-Nar) to be replaced by cleaner technologies relying on fuel type and efficient process and equipment controls (e.g. Low NOx Burners). Programmes are also underway to shift vehicles to use natural gas and low-sulphur diesel.

In all field, modelled and reported emission inventories, Green House Gases are the predominate pollutants; as they account for nearly 99% of emissions of all oil and gas sector stacks and the power and water sector. UAE has recently signed the Kyoto Protocol and currently preparing its first communication to the Convention of Parties. Long term strategic planning has to be initiated at this stage in order to seek cleaner technologies as required by the Protocol.

3.3.9 Future Actions

Abu Dhabi Air Quality Management Project

An overall objective of the air quality management system is to obtain a better understanding of the urban, residential and industrial air pollution as a prerequisite for finding effective solutions to air quality problems and for sustainable development in the environment of the emirate.

Included in this is to identify areas where the Air Quality Limit values are exceeded and to identify possible actions to reduce the pollution load and to improve the general environmental conditions.

The main purpose of the air quality monitoring network will be to monitor and collect ambient air pollution levels in selected areas of the emirate. The measurements will cover areas of impact from various sources of pollution.

To enable evaluation and assessments of air quality and to enable trend analyses a network of fixed stations is to be established. In addition, a mobile station to be deployed at other selected areas of interest for shorter period is required. Furthermore, meteorological stations to provide on-line meteorological data will be established in connection with some of the air quality stations.

The Air Quality and Meteorological stations shall transfer all collected data regularly to a database to be established at EAD premises in Abu Dhabi city. Relevant monitoring software to display and ensure QA/QC check of the data is necessary both at the monitoring stations and at EAD. In addition to air quality and meteorology the network shall also monitor noise at all locations.

ADNOC Air Quality Management Plans

ADNOC are in the process of installing six ambient air quality monitoring stations at selected locations, which shall also be connected to the Emirate-wide network managed by EAD. ADNOC are also in the process of installing on-line stack monitoring devices for selected emission sources. The devices will be connected to a database platform that would enable management of emissions and emission dispersion modeling. The latter will enable forecasting of future air quality trends as a result of new projects, thus enabling mitigation of such impacts.

ADWEA Air Quality Management Plans

Overall, ADWEA aims to install an air quality monitoring station at each of their power plants, and these stations will be connected to the Emirate-wide network managed by EAD. They are also in the process of implementing a recently acquired software for stack emission dispersion modeling.

Compressed Natural Gas

Compressed Natural Gas (CNG) was introduced into Abu Dhabi market on pilot basis, targeting taxis, trucks and government vehicles. This involves converting vehicles, setting up a specialized filling station, and constructing an underground supply pipeline. If successful, the longer-term goal is to use natural gas to fuel all Abu Dhabi taxis, and then extend it to cover other transportation such as buses and trucks.

Low Sulphur Fuel

Agreement in principle has been reached between the Ministry of Petroleum and Mineral Resources, the Emirates Authority for Standardization & Metrology, Federal Environment Agency and national oil companies for a step reduction in the sulphur content of gas oil (fuel used for diesel trucks) supplied to the local market. This is planned to decrease from the current level of 5,000 PPM to 2,500 PPM by the end of 2005, and to 50 PPM by the end of 2010.

Strategic Environmental Assessment

In light of the massive and unparalleled development seen by Abu Dhabi Emirate in the recent years and which is expected to boom further in the future, it is suggested that cross-over instrument be devised, instated and implemented to account for all these growing factors on the decreasing environmental resources. Several countries have reached beyond the project specific environmental impact assessment studies (EIAs) into a bird-eye environmental study approach referred to as Strategic Environmental Assessment (SEA).

Strategic Environmental Assessment (SEA) is a "proactive instrument for integrating environmental considerations into spatial and sectoral policies/plans/programmes (PPP) formation for suitable development." (IAIA, 2002). As there is a wide variety of PPPs being considered under different circumstances, SEA needs to be both systematic and flexible, providing the best available environmental information and advice to decision makers to improve the environmental performance of their proposed PPPs.

While there are different definitions adopted in different countries, it is generally agreed that SEA is a systematic process for evaluating strategic environmental implications of proposed policies, plans and programmes (PPPs) and alternatives during the early stage of decision-making process. SEA has been widely adopted in many countries as a tool to facilitate integration of environmental considerations into PPP formulation processes and to facilitate the achievement of long term sustainability.

Benefits and values would be added to the formulation of policies, plans and programmes through implementation of this process and lead to environmentally sustainable outcomes when SEA is applied properly at the earliest possible stage, coincided with the formulation of policies, plans and programmes. The goal is to provide adequate, timely and useful environmental information when crucial decisions are made.

SEA is essential for informed decision-making. The aims of SEA are:

- To facilitate the search of sustainable development options or alternatives.
- To provide environmental information (including both adverse impacts and benefits) at the earliest stage of PPP formulation processes within a decision-making framework.
- To inform decision makers and the public about the environmental and sustainability implications of PPPs so as to improve decision making processes.
- To address cumulative environmental impacts that cannot be fully addressed by individual project Environmental Impact Assessment (EIA).

These aims assist in achieving the following objectives:

- Promoting full consideration and integration of environmental implications at the early planning stage of major strategic PPPs;
- Seizing opportunities to enhance environmental sustainability and quality; and
- Avoiding environmental problems and identifying environmentally-friendly options

4 SUMMARY (INFORMATION GAPS AND THE WAY FORWARD)

4.1 Waste Management

A fairly large amount of information and first-hand quantitative data was available to the authors regarding the management of non-hazardous domestic effluents, especially regarding facilities operated by Abu Dhabi Municipality until late 1990's. The latter data need updating to reflect recent changes in this sector.

A fairly large amount of information was also available regarding the management of non-hazardous municipal solid waste, but first-hand quantitative data was deficient or lacking. Estimates of waste quantities could only be obtained from consultant reports, where they are derived indirectly based on limited surveys or by applying certain factors and assumptions.

A reasonable amount of information was available regarding the management of hazardous medical wastes from health care facilities and liquid and solid hazardous wastes from the oil industry, in addition to some waste quantitative data for each sector. However, there were clear gaps in the information and quantitative data related to the management of hazardous wastes from non-oil industries. More concrete relevant data expect to be collected through greater EAD involvement in waste management, including through a manifest system to track wastes handled by generators and ESPs outside the oil sector, and a corresponding manifest system implemented by ADNOC companies to track hazardous wastes generated by the oil sector. A mechanism is needed to communicate the latter data to EAD.

4.2 Marine Environmental Quality

Only a limited amount of data on marine environment quality was available to the authors in readily accessible form in published reports and studies. This gap shall gradually be bridged by monitoring activities started by concerneddepartments within EAD, as well as by ADWEA, ADNOC and other concerned authorities. Mechanisms are required to bring all these data sets together.

In addition, a wealth of data and information is contained within EIA and baseline survey reports being submitted as part of environmental permitting activities at EAD. However, a mechanism is required to bring all these data and information together, based on softcopy versions of the reports that are already being submitted in non-pdf formats.

4.3 Air Quality

A fairly large amount of information on ambient air quality is already available, and additional such data are being continuously collected by the existing monitoring stations now being operated by EAD. Estimates of emissions from main pollution sources are also available. In future, more data shall be generated and collected in a systematic way when a comprehensive air-quality management project being implemented by EAD is finalized, through provision of more monitoring stations and a central data processing station, outsourcing of services related to the maintenance and operation of the monitoring stations, and increased participation of private laboratories in stack emission monitoring and reporting. Additional data shall be collected through EIA and baseline survey reports submitted to EAD for environmental permitting purposes.

4.4 Overall

The paper tried to cover as many waste streams as possible based mostly on information that is readily available in secondary sources (see Annex 2). It is admitted, however, that some waste streams were covered only slightly or not at all at this stage, mostly for the lack of pertinent information with the authors. It is anticipated that this problem will gradually be resolved as people from other agencies get involved in the review of this sector paper and in preparing sector papers in subsequent years. Such increased participation is the only guarantor for presenting a wider database that is more representative of the situation in Abu Dhabi Emirate.

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- Oil sector hazardous wastes (Section 3.1.4).
- Medical waste management within ADNOC (within Section 3.1.6).
- Sewage management within ADNOC (within Section 3.2.1).
- Gasoline underground storage tanks (Section 3.2.5).

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Provided a report (Qawasmeh, 2005) compiling key findings of five reports (Guerreiro & Nour, 2004; Bohler et al., 2004; Bohler & Gamal, 2005; Bohler et al., 2005; Guerreiro, 2005) that presented findings so far of the Abu Dhabi-wide Air Quality Monitoring and Management Project. The report thus produced was re-written and condensed into Section 3.3 of this paper.

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Appendix 1: Glossary of Terms and Abbreviations

AAIC Al-Ain Industrial City

AAM Al-Ain Municipality

AD Abu Dhabi

ADCHMMS Abu Dhabi Chemicals and Hazardous Materials Management System

ADCO Abu Dhabi Company for Onshore Oil Operations

ADGAS Abu Dhabi Gas Liquefaction Limited

ADM Abu Dhabi Municipality

ADMA-OPCO Abu Dhabi Marine Operating Company

ADNATCO Abu Dhabi National Tanker Company

ADNOC Abu Dhabi National Oil Company

ADNOC-

DSTRIBUTION Abu Dhabi National Oil Company For Distribution

ADOC Abu Dhabi Oil Company

ADWEA Abu Dhabi Water and Electricity Authority

AED Arab Emirates Dirham

APC Arabian Power Company

ATG Automated Tank Gauging System

BeAAT Central Environmental Protection Facility at Ruwais (belongs to ADNOC)

BOD Biochemical oxygen demand

BOO Build, Own, Operate (privatization model)

BOOT Build, Own, Operate, Transfer (privatization model)

BOROUGE Abu Dhabi Polymers Company

BPC Baynunah Power Company

Bpd Barrel per day

BPSD Barrels per stream day

BSCFD Billion standard cubic feet per day

BUNDUQ Bunduq Limited Company

CA Concerned authority

CD Civil Defense

C&D Construction and Demolition (waste related)

CDM Clean Development Mechanism

COD Chemical oxygen demand

CP Cleaner Production

DPE Department of Planning and Economy

EAD Environment Agency -Abu Dhabi (formerly ERWDA)

EC European Commission

ECMC Emirates CMS Power Company

EIA Environmental impact assessment

EPA Environmental Protection Agency (USA)

EPD Environment Protection Department, EAD

ESP Environmental Service Provider

ERWDA Environmental Research and Wildlife Development Agency (now EAD)

ESP Environmental Service Provider

FAO Food and Agriculture Organization

FEA Federal Environmental Agency

FECC Food and Environment Control Center (of the Municipality)

FERTIL Ruwais Fertilizer Industries

GAHS General Authority of Health Services in Abu Dhabi Emirate

GASCO Abu Dhabi Gas Industries Limited

GRP Glass reinforced plastic

GT Gas Turbine

ICAD Industrial City of Abu Dhabi

HCSEZ Higher Corporation for Specialized Economic Zones

HHW Household Hazardous Wastes

HRSG Heat Recovery Steam Generator

IAEA International Atomic Energy Agency

IRSHAD Abu Dhabi Petroleum Ports Operating Company

LNG Liquefied natural gas

LPG Liquefied petroleum gas

LUST Leaking underground storage tank

MAF Ministry of Agriculture and Fisheries

MEW Ministry of Electricity and Water (now Ministry of Energy)

MOD Ministry of Defense;

MOE Ministry of Energy (formerly Ministry of Electricity and Water)

MOI Ministry of Interior

MPC Mirfa Power Company

MRL Maximum residue level (allowable, of a pesticide in a food commodity)

MSCFD Million Standard Cubic Feet per Day

MSCMD Million Standard Cubic Meters Per Day

MSF Multi Stage Flash Desalination unit

MSW Municipal solid waste

NDC National Drilling Company

NGL Natural Gas Liquid

NGSCO National Gas Shipping Company

NPCC National Petroleum Construction Company

POE Point of entry (custom related)

PVC Polyvinyl chloride

RO Reverse osmosis

ROPME Regional Organization for the Protection of the Marine Environment

SCMY Standard Cubic Meter per Year

SPC Sewerage Projects Committee of Abu Dhabi Municipality

SS Suspended solids

ST Steam Turbine

STP Sewage Treatment Plant

TAKREER Abu Dhabi Oil Refining Company

TAPCO Taweelah Asia Power Company

TCC Traffic Control Center

TDS Total dissolved solids

THW Toxic and hazardous waste

TOTAL-ABK Total Abu Al Bukhoosh

TSS Total suspended solids

TTE O&M Total Tractebel Emirates O&M Company

UAE United Arab Emirates

UN United Nations

UAN Umm Al-Nar

USA United States of America

UST Underground storage tank

VOC Volatile organic compound

WHO World Health Organization

ZADCO Zakum Development Company

Appendix 2: Paper Scope of Work and Process

The scope and outline of the paper were decided in the "Waste Management and Pollution" workshop on May 30, 2005. During this workshop, participants form other agencies suggested that EAD and AGEDI secretariat need to contact higher management of their respective organizations before they could commit to participate in writing the paper or in contributing to it. Given that EAD has already formed a Committee on the Management of Medical and Hazardous Wastes in Abu Dhabi Emirate, which included members from key concerned parties (Abu Dhabi and Al-Ain municipalities, ADNOC, ADWEA, GAHS), it was decided that the required commitment and contributions could best be achieved through members of this committee The issue was raised with committee members first in meetings, then through direct correspondence in July 2005.

A questionnaire was prepared and distributed to committee members. The questionnaire included a table and instructions for filling it and for providing the required feedback. The table reproduced in its first column the pre-agreed paper outline, identified in its second column the candidate contributor agencies for covering each topic, and provided additional columns for committee members to indicate the following:

1. Their review and acceptance of paper outline, structure and content. Otherwise, they were requested to suggest changes.

2. Whether they or their respective organizations have any key references that they will use or are of value to any section of the paper. Members were asked to provide copies of such key references.

3. Sections that the member would prepare or supervise preparation by other members of his organization. If neither, members were asked to nominate others who can cover certain sections of the paper.

4. The time required to complete any section they agree / elect to prepare or supervise preparation.

Acceptable feedback information and statistics were received only from ADNOC member, who indicted (verbally) inability to contribute to the writing of the paper.

Accordingly, the paper was written / prepared entirely by staff from EAD's Environment Protection Department (EPD) based on secondary information sources, notably EPD publications, available consultant reports and general publications of the other agencies. A number of issues related to recent developments in sewage management were not sufficiently covered by available sources and were raised by letter with the concerned organizations. Replies were still not received until the date of submission of this paper.

Every effort was made to collect as much information as required to cover the pre-agreed scope of the paper, and to present the information in the pre-agreed format. However, changes had to be introduced in the scope as well as in the presentation, based on the quantity and quality of the information that could ultimately be collected.

The draft paper submitted in December 2005 was posted on AGEDI web site (http://portal.agedi.ae). Stakeholder agencies were requested, in writing, first to review the paper and provide feedback, then to attend a meeting on 22 March 2006 to discuss the same. However, no comments were received in writing until the meeting, which was attended by representatives of only ADWEA and ADNOC, whose comments were considered in revising the paper.

Since the draft paper was submitted, the wastes and pollution management sector in Abu Dhabi witnessed several developments, and is poised to witness more developments on the short term. Instead of keep changing the paper to catch up with developments, recent developments are summarized in a preface to the paper, and its body is kept mostly unchanged, so that it reflects the status of waste management and pollution control aspects in Abu Dhabi Emirate as of December 2005. Changes were introduced in the body of the paper only to correct errors, delete sensitive information, or elaborate on certain issues as deemed necessary by reviewers of the paper

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