

## **AIR QUALITY MANAGEMENT IN THE AQABA SPECIAL ECONOMIC ZONE (ASEZA), JORDAN**

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### **INTRODUCTION**

The Aqaba Special Economic Zone (ASEZ) was created, in 2001, to attract and facilitate investment in the areas of tourism, industry, port development, infrastructure, utilities and services. It is imperative that all such development remains environmentally sustainable in the long term, since the environmental resources of the area are themselves an integral part of its attraction to investment.

As Aqaba embarks on an extensive economic development with tourism as a major focus of its expansion, the need for a pristine environment will be top priority. An enormous project for the development of a tourist village at Tala Bay (15 kilometers to the south of Aqaba city) is presently underway. Another Mega projects are also on underway; the Ayla Oasis and Saraya.

Tala Bay village will be at the edge of the southern Coral Marine Reserve area. What makes it of special concern is that this village will be only ~3 kilometers to the north of the industrial zone. Several hills and mountain ridges will separate the two zones. This tourist village will have dwellings accommodation for 35,000 tourists with three international hotels, an inland marina, golf course and various parks and recreation areas.

For tourism to flourish, the main attractions are good accommodation and recreation, mild weather and pristine environment. The major portions of tourists usually are the elderly and the very young. This sector of society is the most vulnerable sector to environmental pollution. Therefore, preservation of a clean environment will be the main attraction to the region of Aqaba.

### **THE AQABA SPECIAL ECONOMIC ZONE**

#### ***An Overview***

The Gulf of Aqaba is 180 kilometers long and 14–26 kilometers wide with an average depth of 800 meters. The Gulf is an inland extension of the Red Sea. It contains a unique diversity of fauna and flora that is being threatened by recent urban development including: tourism and industrial expansion, fish farming together with the increase in shipping and overland transportation.

The portion of the Gulf within Jordanian jurisdiction covers the stretch that extends from the extreme northeastern end of the Gulf southward for 26.5 kilometers to the border of Saudi Arabia with the city of Aqaba located at the tip of this stretch. The Jordanian side of the Gulf has witnessed the expansion of the port and storage area, the construction of a large electrical power generation station and the expansion and development of fertilizer production industries at the industrial area (located about 20 Kilometres south of the city of Aqaba). Tourism have also expanded with the necessary construction and planning of new hotels, restaurants, beachside concessions and roads.

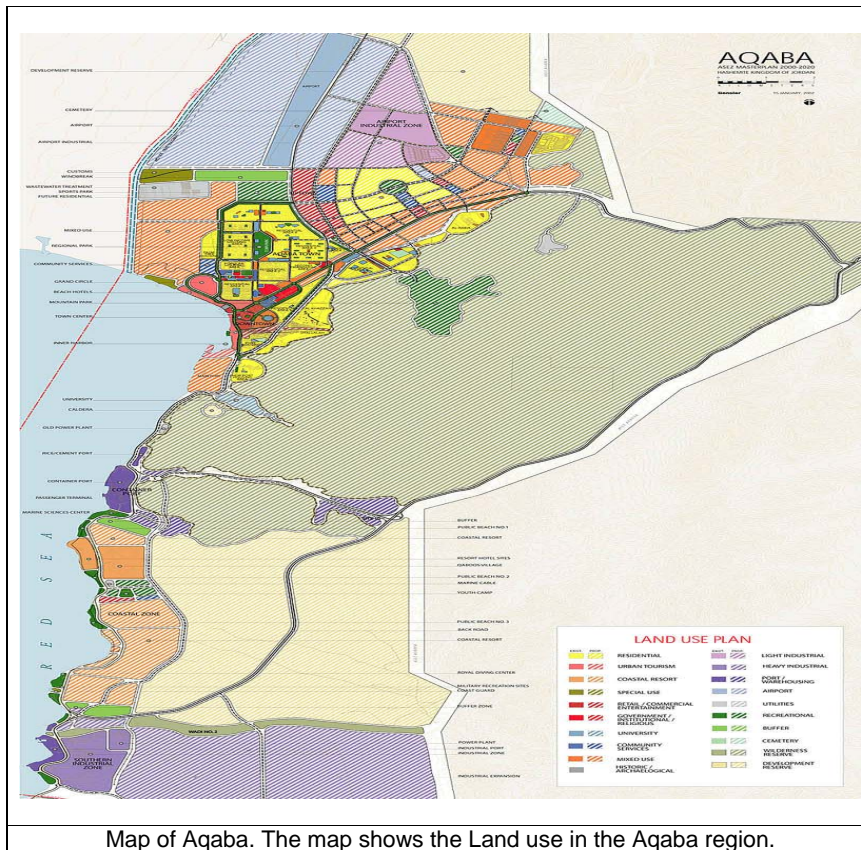
The Port of Aqaba is Jordan's only outlet to the sea. During the last three decades, the Port of Aqaba has witnessed an accelerated growth in population and economic development. Since 1972, the city has expanded from a small urban community of 10,000 inhabitants to more than 85,000. The major reasons for economic growth could be attributed to rapid industrial development, expansion in export-import activities and tourism, which represent the third largest income earner.

These diversified activities have brought with them an increase in various types of overland transportation. This increase included passenger vehicles, and trucks loaded with bulk/cargo shipments from and to Aqaba port. As the industrial activities increase, raw material carried by heavy-duty trucks also increased to meet demands.

Recently, new highways that bypass urban areas were opened for the purposes of diverting the major portion of truck traffics to and from the industrial sector. Trucks, hauling raw materials to and from the industrial sector no longer pass through urban streets. This has resulted in reducing fugitive dusts and air particulates that contributed significantly to contaminating urban atmosphere.

### ***Topography***

Mountain ridges cover the region with elevations reaching up to 1600 meters perpendicular to the shoreline and interrupted by a series of intermittent valleys of various widths. This network of valleys acts as wind channels that are eventually responsible for the erratic behaviour of the wind direction in the vicinity of the Gulf shoreline. The coastal areas experience various changes in wind direction and temperature. This topography allows wind channelling from land through valleys to develop and in the afternoon winds with weak gulf breezes will also have some effect on the general circulation. Re-circulation of air due to offshore followed by onshore breezes could develop on occasions.



Map of Aqaba. The map shows the Land use in the Aqaba region.

### *Climatology*

The climate is arid with an average annual rainfall of about 30 millimetres. The mean daily air temperature ranges from 14 °C in January to more than 35°C in August. On substrate rocky beaches, temperature may reach up to 50 °C during the summer months. Relative humidity ranges from 30 to 55 percent. The prevailing winds are primarily from the north (81 %) with about 7% originating from the south. Days with calm winds account for 12 % of the time.

Periods of poor dispersion occur during winter and late autumn as a result of slow-moving anticyclones, typified by light winds and low mixing heights. This is a major mechanism for PM-10 events. Air dispersion patterns will be influenced by the Gulf and the surrounding hills.

## **ENVIRONMENTAL POLICY IN THE ZONE**

ASEZA has adopted a number of policies associated with the control, management and protection of the natural environment. The environmental policy requires preservation and protection of the environment and the sustained development of the Zone's natural resources. The water policy requires the protection and management of the groundwater resources, as well as the development of wastewater management and reuse schemes. Water conservation is to be enhanced by managing both supply and demand and efficiency of use. The energy conservation policy promotes the provision of adequate energy to consumers at the least possible cost. A stringent discharge policy of "Zero Discharge" to the sea was also adopted, to preserve the marine environment through the complete elimination of marine pollution. The Gulf of Aqaba is defined as a 'special area' according to the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) signifying that discharges of oil are prohibited from vessels.

The Environmental Protection Regulation (EPR) No. 21 of the year 2001, provides a basis for the environmental policies in the Zone. It lists a number of prohibited acts regarding waste management, use of sea Water, and emission of harmful substances to the environment. The regulation addresses the legal framework for environmental management and monitoring in the Zone including environmental clearance and post-clearance phases of the economic activities in the Zone. The regulation also details appropriate measures to prevent environmental pollution and protect the marine resources, and set out a legal framework for the imposition of penalties for pollution incidents

ASEZA requires that all existing and potential investors within the Zone to comply with the EPR No. 21. This article addresses, particularly the air quality management in the Zone.

## **AIR QUALITY IN ASEZ**

### **Air Quality Assessment**

The major source of air pollution in the region is fossil fuel combustion resulting from industrial activities and other processes. The fuel used contains between 3.5-4% sulfur together with other industrial processes have increased the concentration of SO<sub>2</sub> in the ambient air. The sources for solid particulates in the region are: windblown dust from dry soil; local re-entrained dust emissions from roads together with the combustion of fossil fuels; industrial processes; transporting and handling of phosphate rocks and other raw materials such as potash as well as the photochemical reactions and dry deposition of pollutants in the atmosphere. As vehicular traffic increases, motor vehicles will contribute to various pollutants in the ambient air.

In this regard, the U.S. Agency for International Development (USAID) supported a study on the air quality assessment in the Zone. The survey estimated emissions of some major air pollutants from the existing industries as SO<sub>2</sub>, PM, NH<sub>3</sub> & HF. In addition, it showed that data on ambient air quality were few and scattered. Therefore, continuous and reliable source of air pollution measurement is needed for obtaining general trends and achieving any meaningful correlation for long-term predictions.

The assessment was conducted produced by Dr. Fouad Kanbour in the year 2003. The study estimated emissions of some air pollutants from the existing industries as around 72500 ton/yr of SO<sub>2</sub>, 48500 ton/yr of PM and 15000 ton/yr of F & HF. This regional load of pollutants has increased when KEMAPCO began production.

Table 1 shows the estimated emission in ton/yr from the various industrial activities in Aqaba. Large increase of NO<sub>x</sub> with lesser increase of SO<sub>2</sub> and solid particulate pollutants was observed in the ambient air when production at KEMAPCO commenced. The increase in NO<sub>x</sub> concentration will eventually increase the ozone concentration during the summer and fall months.

Table 1. Estimated emissions of the industries in ASEZ

Deleted :

The yr 2000	Power Plant	Industrial Complex					NJFC	Total Ton /y
		H <sub>3</sub> PO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	AlF <sub>3</sub>	DAP	Utility		
SO <sub>2</sub>	67400	-	23	42	1260	3680	130	72500
SO <sub>3</sub>	820	-	1.3	0.6	15.3	46	1.5	885
PM	4820	33900	245	15	90	270	9	39500
CO	600	-	-	2.5	11.2	34	1.1	650
NO <sub>x</sub>	4961	-	-	9.9	149	446	1	5600
VOC	119	-	-	0.1	2.2	6.7	0.01	130
NH <sub>3</sub>	-	-	-	-	#2345	-	1225	3600
F, (HF)	-	14805	-	*(3.5)	# 154	-	35	15000

Fuel oil; S = 3.6%; Diesel Oil S = 0.6 %,

▪ Assuming efficient control; # According to actual emission calculation

One must realize sources other than industrial activities will also contribute to the total load of regional pollution. The other anthropogenic sources are motor vehicles, trucks, ships, and planes as well as evaporations from chemical and fuel storage tanks. Natural dust as well as anthropogenic pollutants from neighbouring cities will also contribute to the degradation of air quality in Aqaba.

The study recommended that an ambient air monitoring program to be initiated and implemented as soon as possible by ASEZA in coordination with other regional stakeholders. Monitoring programs will provide scientific basis for the development of policy and strategy and setting objectives, and carrying out compliance measurement and enforcement action against targets. Data collected from monitoring

will elucidate urban population exposure to pollutants and the possible threat to the natural ecosystem.

### **Air Quality Management**

In response to the recommendations outlined by the air quality assessment, ASEZA has requested an engineering firm to carry out specialized study to resolve the dust emissions in the port, enforced the industrial stack emissions monitoring program, prioritised the establishments of an ambient air quality monitoring network through the funding agencies as well as the participation in a revision of the national air-quality standards to support the enforcement of the EPR in the Zone. These actions will be discussed further in the following sub-sections.

### ***Alternatives For Resolving The Fugitive Dust Issues At The Aqaba Phosphate Export Terminal***

The U.S. Agency for International Development (USAID) to support development of ASEZ funded this study that was conducted by Collins Engineers in 2004.

The study examined the alternatives for cleaning up the fugitive dust problem at the Aqaba Phosphate Rock Export Terminal in the main port of Aqaba. The existing terminal has a problem with too much phosphate dust being discharged to the atmosphere and the marine environment, and this will negatively affect the growth of tourism and the environmental quality of the Gulf of Aqaba. The negative impacts are both aesthetic (the visible cloud of dust) and detrimental to coral growth as a result of siltation and turbidity in coastal waters primarily south of the terminal.

The study addressed two major alternatives: one which involves relocating the entire operation and facilities to the Southern Industrial Zone approximately 15 Km to the south and the second which involves making the capital improvements to the existing facility that would be necessary to clean up the terminal to acceptable levels of fugitive dust. The alternative of making capital improvements to the existing facility was further divided into a series of actions, each of which would result in a recognizable reduction in the fugitive dust escaping the facility.

The alternative of cleaning up the existing facility included such measures as the addition of more vacuum filtration systems, use of fabric hatch covers, expansion and closure of buildings receiving phosphate by truck, paving and cleaning of the site, and improving the existing rail receiving buildings. The study estimated the approximate percentage of dust reduction that could be achieved by each potential, discrete improvement and the probable cost of those improvements.

The estimated cost of relocating the facility to the Southern Industrial Zone is \$248 million USD, including the cost for extending rail facilities to the new site. The estimated cost for making all of the improvements needed at the site to bring the dust discharges down to an acceptable level that would be compatible with the continued expansion of tourism would run an estimated \$18.3 million USD.

The study recommends that a series of discrete capital and maintenance improvements be undertaken to reduce fugitive dust escaping the existing phosphate export terminal to levels that will not cause problems with the marine environment or tourism development. It also provides estimates of the costs for doing this in a progressive manner, as funds are available. Finally, it addresses means necessary to ensure maintenance is properly done to keep the dust under control.

These findings were communicated to the Aqaba Development Corporation (ADC). ADC was established in 2004 to drive the investment and development in the Zone and currently owns the port. Resolving of the dust issue is being considered in their master plan of the Zone and is being followed closely by ASEZA.

**Industries self-Monitoring Program: Stack Emissions**

ASEZA identified the various pollutants that are generated from the various industrial activities in Aqaba. Table 2 summarizes these pollutants.

Industries in the zone were engaged in self-monitoring programs on their stack emissions. The results of these programs are reported to ASEZA on a regular basis. ASEZA is working closely with the industries to reduce these emissions and to comply with the Jordanian standards.

In case of violation to the standard and as per the EPR, Corrective- Actions will be send to the industries. They will then propose permanent actions with a time frame to resolve the issues and to fully comply with the standards.

The exercise of self-monitoring, reporting and the compliance wit the Jordanian standard was initiated and followed up closely with each industry during 2004. This has resulted in a better cooperation between the industries and ASEZA as regulator. The data is being used to establish database.

Table 2. Emission of pollutants from the various industries in ASEZ

Deleted: :

Industrial Zone	Major Pollutants
Aqaba Thermal Power Plant (APP)	PM, SO <sub>2</sub> , SO <sub>3</sub> , NO <sub>x</sub> , CO, and total organic compounds (TOC).
Jordan Phosphate mining Company (JPMC)	PM, SO <sub>2</sub> , SO <sub>3</sub> , HF, SiF <sub>4</sub> , NH <sub>3</sub> , NO <sub>x</sub> , CO.
Nippon- Jordan Fertilizer plant (NJFC)	PM, SO <sub>2</sub> , SO <sub>3</sub> , NO <sub>x</sub> , CO HF, NH <sub>3</sub>
Arab Potash Storage Plant (APC)	PM
Jordan Safi Salt	PM
Jordan Cement Storage	PM
The Port Authority (KEMAPCO)	PM, NH <sub>3</sub>
	PM, SO <sub>2</sub> , NO <sub>2</sub> , HF, SiF <sub>4</sub> , NH <sub>3</sub> , CO.

One of the main achievements in the Zone was the introduction of the natural gas through underwater pipeline. ASEZA assisted and facilitated the completion of the gas line and closely follow up the progress of the conversion from heavy fuel oil to gas. ATPP was the first to convert from using heavy fuel oil to the natural gas eliminating the major contribution of SO<sub>x</sub> to the atmosphere.

#### ***Establishment of ASEZA Ambient Air Quality Monitoring Network***

ASEZA, with the assistance of the European Union, and as a part of the Institutional Support to the Aqaba Special Economic Zone Authority (IS-ASEZA) program is establishing an air quality-monitoring network as well as purchasing the necessary equipment for the verification of the industrial stack emissions.

One of the major objectives of the program is to provide ASEZA with operational and fully equipped laboratories for the analysis of environmental pollution, certified and accredited to international standards.

ASEZA staff will be trained to operate, maintain and trouble shoot the network as well as able to analyse samples in the environmental laboratory. Staff will also be able to utilize the environmental models and associated software”.

The monitoring network is to be operated and maintained by Jordanian experts. The data obtained within the network will be employed in situation assessment, ensuring that accurate information is delivered to the public.

It will enable ASEZA to assess risks for public health from amongst others air pollution, enforce air quality legislation, and to make informed decisions and plans for the improvement of air quality throughout ASEZ. It will also assist the Jordanian authorities in their endeavours to improve air quality/air quality standards throughout ASEZ/Jordan.

One fixed monitoring station will be delivered plus one mobile station. As a matter of principle the parameters, as identified in Annex 1 of the 96/62/EC Directive, will be included in the list of parameters, taking into account the following amendments because of the specific situation in Aqaba.

The fixed station (North of Aqaba) is designated as residential/City Centre type station measuring the impact of traffic and possible industrial emissions reaches the city on ambient air quality.

The mobile station will be used for measurements in the industrial sources, City Centre as well as in residential areas.



Parameter	Continuous measurement?	Remarks
Parameters based on the 96/62/EC directive		
SO <sub>2</sub>	Yes	Substantial emissions by local industry south of Aqaba
NO <sub>2</sub>	Yes	A possibly important substance emitted by industry and transport and produced in the atmosphere
O <sub>3</sub>	Yes	Produced by precursors in combination with sun light, may be relevant
CO	Yes	Substance emitted by industry and transport
PM10 and PM2.5	Yes	PM2.5 is added to the list because since 1996 it appeared that the PM2.5 fraction of dust in air is of special importance for human health. Most EU countries have amended their system, or have the capability, to measure also PM2.5. PM 10 should still be measured because the EU and other international ambient air quality standards are still in terms of PM10. SPM (total dust in air) will not be measured continuously although this is still specified in the above EU directive. However, it will be possible to measure SPM off line with samplers.
VOC	Yes	Emitted by industry and transport
Lead, cadmium, arsenic, nickel, mercury	No, off line	Lead from transport and industry; cadmium from especially the rock phosphate industry south of Aqaba
PAHs	No, off line	Industry and transport are relevant sources
Parameters in addition to the 96/62/EC directive		
Ammonia	Yes	Ammonia processing industry south of Aqaba, also a potential short term risk
Fluoride	Yes	Large local sources from especially the rock phosphate industry south of Aqaba

## CONCLUSIONS

Since its establishment, air quality was a major concern to the commission for Environment at ASEZA. The following step were taken to ensure that air quality is being managed in the zone:

- Introducing the necessary regulations to protect the environment

- Assessment of the air quality
- Engaging the industries in the “stack-emissions self-monitoring program”
- Studying alternatives to resolve the phosphate Dust-emission at the port
- Facilitating the introduction of the natural gas in the zone and encouraging industries to convert from the use of heavy fuel oil.
- Establishing air monitoring network to investigate complaints and assess the impact of pollution on man and his environment; obtain continuous and reliable data of regional air pollutants; assures compliance with ambient air quality standards and emission standards as well as the application of dispersion models and carry out prediction for future plans of industrial and tourism expansion. Data collected from monitoring will elucidate urban population exposure to pollutants and the possible threat to the natural ecosystem.

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#### **REFERENCES**

1. Collins Engineers (2004). *Alternatives For Resolving The Fugitive Dust Issues At The Aqaba Phosphate Export Terminal*. The Services Group under the Aqaba Technical Assistance Support Project (ATASP). ATASP is funded by the U.S. Agency for International Development (USAID) to support development of the Aqaba Special Economic Zone (ASEZ) in Aqaba, Jordan. 2004
2. IS-ASEZA (2004). *Overall work-plan, The Institutional Support to the Aqaba Special Economic Zone Authority (IS-ASEZA)*.
3. Kanbour, F. (2003). *Design and specifications of Ambient air monitoring System Report*. The Services Group under the Aqaba Technical Assistance Support Project (ATASP). ATASP is funded by the U.S. Agency for International Development (USAID) to support development of the Aqaba Special Economic Zone (ASEZ) in Aqaba, Jordan.
4. [www.aqabazone.jo](http://www.aqabazone.jo)