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ENVIRONMENTAL MANAGEMENT IN THE OIL REFINING AND PETROCHEMICAL INDUSTRY IN WESTERN ASIA: A REGIONAL PERSPECTIVE

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CONTENTS

Annexes

List of annex tables

INTRODUCTION

Pollution emanating from petroleum refining continues to increase in the ESCWA region as refining capacity has expanded at a rapid pace. In 1986, the estimated production capacity was 3.9 million barrels/day (bbl/day). As a consequence, ecodegradation has tended to accelerate as old refineries discharged their effluent into rivers and semi-enclosed seas that are highly susceptible to the debilitating effects of oil pollution. Governments are cognizant of the economic impact of industrial pollution; some oil-producing countries have commenced programmes that will assist refineries to adopt appropriate pollution control technology, and to finance the facilities required to ensure abatement at source.

In the past decade, the petroleum industry in Western Asia has implemented several measures in an effort to modify processes and introduce state-of-the-art technologies which eventually lead to a reduction in emissions from oil refineries, as well as the content of sulphur in fuels sold for public consumption. Through various desulpherization processes and the gradual switch to unleaded gasoline, sulphur dioxide and lead emissions have been brought down to much lower levels compared with the levels in the early 1970s.

The move towards the control of gaseous emissions, increased treatment and the recycling of waste water; and the proper handling of sludges, spent catalysts and other hazardous solid wastes from oil refineries is timely, and will undoubtedly help to reduce the load of industrial emissions in the region. New approaches and technological developments designed to limit the release of emissions need to be pursued in the future in order to avoid or further reduce pollution emanating from oil-refining. New technologies such as the land-farming of sludges, the increased removal of oil by coalescence prior to the biological treatment of process effluents, and the improved stripping of gases have already been introduced in some refineries in the region and are expected to be adopted by many others in the near future.

The petrochemical industry has broadened its feedstock from the mere treatment of organic residues from the refining process, to the processing of crude petroleum, natural gas, refinery gas and high fractions such as naphta or heavy fractions like fuel-oil or coal. The new trend is towards the control of pollution through process improvements, rather than end-of-pipe treatment. The petrochemical industry, though still in its infancy in Western Asia, is now aware of its responsibility to protect both the environment and the well-being of the community. The objective is to increase the economic viability of the industry, while at the same time operating in a safe and clean environment. The industry has made considerable progress towards the optimization of production processes and reduction of the generated wastes. Nevertheless, it should be pointed out that the production of petrochemicals is a dynamic industry that requires an equal effort to combat pollution emanating from new processing operations and to reduce the hazards of newly developed products.

I. PETROLEUM REFINING PROCESSES

Petroleum is a mixture of organic compounds and primary hydrocarbons that result from underground formation over extended periods of time. Major products can be produced from crude oil by a series of simple physical separation processes; however, some products may require further processing in order to improve their quality. This can be achieved through complex process operations including the separation of molecular constituents, cracking, molecular rebuilding and solvent-finishing that will produce various petroleum products.

Faced with a progressive demand for sophisticated products, refineries are expanding conversion facilities such as fluid catalytic cracking, vis-breading, thermal cracking, coking and hydrocracking, in order to convert heavy products into more desirable lighter ones.

Growing concern over environmental issues has dictated the use of new upgrading facilities such as catalytic reforming that provides high octane components for unleaded gasoline, and advanced desulphurization which meets the demand for lower limits on the sulphur content of heating gas oil and diesel fuel. These new technologies have drastically reduced the level of sulphur and sulphur dioxide emissions from refineries that result from the combustion of treated oil products.

Refining utilizes various physical and chemical processes in order to produce the quantity and quality of products desired.

The major processing operations include the following:

(a) Desalting: a pre-treatment process used to remove dissolved salts from crude oil in order to eliminate subsequent operational problems such as scaling, corrosion and poisoning of the cracking catalysts. Water is added to crude oil at an elevated temperature to form a water-oil emulsion. This emulsion is destalligied by applying an electrostatic field or by adding chemical de-emulsifiers;

(b) Distillation: the core process used for the separation of intermediate fractions according to a specific boiling point range. The steam used for distillation is separated by gravity upon the condensation of each fraction. These condensates are heavily polluted and usually contain appreciable amounts of sulphides, ammonia, chlorides, mercaptans and phenols;

(c) Cracking: thermal cracking involves breaking larger molecules into lower molecular-weight fractions (gasoline). Catalytic cracking involves the use of catalysts at lower temperatures in order to produce high octane gasoline stocks, and middle molecular weight distilates. Hydrocracking involves catalytic cracking in the presence of hydrogen, operating at a lower temperature and higher pressure than that needed for catalytic cracking. As hydrogen tends to strip sulphur, the condensate usually has a higher sulphide content;

(d) Hydrocarbon rebuilding: high octane gasoline can be produced by polymerization that converts light olefin feedstocks into higher octane polymers. Alkylation consists of an isoparaffin and olefin reaction in the presence of an acid catalyst and hydrofluoric acid in order to produce a branched-chain alkylate;

(e) Reforming: a process of decomposition that converts naphtha and heavy gasoline into high octane gasoline, producing hydrogen as a by-product;

(f) Hydrotreating: a pre-treatment of cracking and reformer feedstocks;

(g) Solvent refining: a process of separation that isolates some objectionable constituents in a specific product which can then be connected to desirable materials. Although solvents are continually recycled, some may be leaked or mixed with process water;

(h) Asphalt production: the residual fraction that can be blended into heavy oil or oxidized to asphalt. The feedstock is usually put into contact with hot air at a temperature of over 200° C in order to obtain asphalt of an improved quality;

(i) Lubricating oil: speciality products that are manufactured from special high-grade feedstocks are usually subjected to treatment in order to remove asphalt, wax and hydrocarbons, whose viscosity is temperature-sensitive. The processes involved include hydrofinishing, de-waxing, hydrorefining, solvent treating, centrifuging, chilling, treating with acid and blending;

(j) Sweetening: this process refers to the removal of hydrogen sulphide, mercaptans and various thio-phenes through treatment with a caustic solution and electrostatic precipitation.

II. POLLUTION SOURCES

Crude oil contains a mixture of hydrocarbons, minor amounts of sulphur, oxygen and nitrogen, and trace metals such as vanadium and nickel. Refining, which involves separation, conversion, treatment and blending, produces a wide range of automotive, aviation and power-generating fuels, lubricants, bitumens and other special products and chemical feedstocks.

Sulphur compounds are malodorous and should be removed or converted into innocuous compounds during refining in order to eliminate odour problems.

Other sources of gaseous emission include the following:

(a) Hydrocarbons from loading and storage, spills and leaks, catalyst regeneration, cooling towers, condensers and oil separators;

(b) Sulphur oxides from boilers, flares, scrubbers, decoking and catalyst regeneration;

(c) Nitrogen oxides from all combustion operations and catalyst regeneration;

(d) Aromatics from chemical processing, condensers, oil separators and asphalt oxidisers;

(e) Particulates from cracking, furnaces, flaring scrubbers and boilers.

Liquid effluent contains the following pollutants:

(1) Oil from accidental contamination (pipe-tracks, spills, etc.), deballasting, blow-down of cooling towers, crude desalting and processing effluents;

(2) Organic and inorganic chemicals such as phenols, thio-phenols, acids, ammonium sulphide and salts emanating from all processing operations, especially desalting, washing and cracking;

(3) Thermal pollution resulting from boiler blow-down, cooling water discharge and rain-water from oil-free areas.

Soild wastes mainly contain catalytic fines from cracking, coke fines, iron sulphides, spent filtering media and sludges from tanks, oil separators and biological treatment.

Noise is usually generated by compressors, gas turbines, vents, heat exchangers and piping systems.

Control technology includes the following:

(i) Reduction of air emissions by vapour recovery systems, cyclon-precipitators, flare gas recovery, caustic scrubbing and steam-stripping;

(ii) Treatment of waste water by separators, flocculation, flotation and biological processes. Recycling of cooling water to remove ammonia, organic carbons and phenol make-ups;

(iii) Solid wastes are generally incinerated or disposed of in sanitary landfills, while noise is abated by local enclosures or sound absorbers.

III. ENVIRONMENTAL IMPLICATIONS OF OIL-BASED INDUSTRIES IN WESTERN ASIA: A BRIEF OUTLOOK

The dramatic changes that have taken place in the ESCWA region in the last three decades can be attributed largely to the rapid increase in revenue generated by the oil sector, which was followed by a sharp decline in oil prices in the mid-1980s. In the past, a major part of oil revenue was earmarked for the development plans of the oil-exporting countries of ESCWA, with the aim of establishing the industrial and socio-economic infrastructure, and of developing the oil sector itself. However, the recent decrease in oil revenues has led to less emphasis being placed on the establishment of new major industries than on the achievement of a more integrated industrial structure, the consolidation of existing industries, and greater efficiency in terms of higher capacity utilization, planning and operation in existing industrial plants.

Despite these positive trends, most development plans have yet to be based on a conscious energy policy. The increased use of energy is attributed to the orientation of production towards an energy-intensive industrial base, the massive increase in the number of cars, and the increased reliance on energy-intensive life-styles.

The pattern of oil production, the expansion in oil-processing capacity and the increased rate of consumption is certain to continue in the foreseeable future in most countries in Western Asia, and with no anticipated breakthrough that could change current trends. The main concern here is the lack of proper consideration for the environmental consequences that are usually associated with oil production, especially when pursued on a large scale - as is the case in the Gulf States.

Unfortunately, the effects of chronic pollution that result from the various operations in the oil sector only become evident after a long time has elapsed, when the original cause has become too difficult to identify. Thus, the results become evident <u>a posteriori</u> when it is too late to avoid them.

The formulation of environmental policies with regard to oil-processing, while difficult, might prove to be crucial for the energy prospects of the ESCWA region as far as environmental quality is concerned.

The following encompasses a review of the major developments that have taken place in the oil industry in the ESCWA region, and the environmental implications envisaged for these operations. The scope will be limited to the countries with major oil-processing operations, that is, to Bahrain, Egypt, Iraq, Kuwait, Qatar, Saudi Arabia and the United Arab Emirates.

A. <u>Bahrain</u>

Bahrain is characterized by its small area and heavy dependence on the oil industry which represents its main income-generating activity. The "indicative plan" on the strategic options for Bahrain (1986-2000) considers the manufacturing sector to be one of the high priority areas that is expected to develop as a major contributor to economic growth. Although the current plan aims at the expansion of gas utilization industries, it also stresses the importance of developing medium-scale industries.

The main oil industry in Bahrain is the BAPCO refinery that was built in 1935 with an initial capacity of 10,800 barrels/day (bbl/day), later uploaded to 250,000 bbl/day. Since the actual production of crude oil in Bahrain does not exceed 60,000 bbl/day, most of the crude oil is imported for refining from Saudi Arabia in order to allow the refinery to work at full capacity.

BAPCO is presently considering a full modernization scheme to enable it to meet the demand for new products. The estimated investment will exceed one billion dollars and the new plant will include state of the art pollution control devices to reduce sulphur, hydrocarbon, nitrogen oxides and other toxic emissions.

As for natural gas, Bahrain has reserves of around 8 trillion cu ft, and production increased from 23,400,000 m^3 in 1973 to 47,750,000 m^3 in 1980. About 30 per cent of gas output is pumped back into the oil reservoirs in order to maintain pressure, while the remaining 70 per cent is employed in the refinery, the power and desalination plants, the aluminum smelter and as feedstock for the petrochemcial plant. With regard to the associated gas produced in the oilfields, a plant with a capacity of 110 million cu ft/day was established in 1979 in the Jabal and Dukhan area. In petrochemicals, Bahrain has established the Gulf Petrochemical Industry Company (GPIC) on a man-made island (an area of 600,000 m^2) with an annual production capacity of 300,000 tons each of ammonia and methanol. (See case history II; IEIA of GPIC).

The energy-intensive and oil-related industries are bound to cause environmental problems if no proper environmental policy is pursued. Environmental conservation is of paramount importance, as Bahrain is an island of only limited size that is situated in the middle of the Gulf where the probability of water pollution is very high.

At present, some measures are being introduced to alleviate the environmental impact of the energy-intensive and oil-based industries in the country. Measures such as the extinction of gas flares in the oilfields, the modernization of the refinery's flare system, the introduction of new systems in industries that cause pollution and the replacement of worn out ones, the monitoring of polluting activities within each plant in order to minimize their environmental impact, etc. However, a comprehensive environment protection policy that will cover the whole oil-producing sector, with its possibly hazardous effects is still needed.

The Environmental Protection Committee (EPC) of Bahrain and its technical secretariat has been empowered (decree 7/1980) to develop and implement environmental legislation, to carry out research in order to identify pollution sources, to monitor emissions levels and to co-ordinate activities on the environmental impact assessment of industry and other development activities. EPC still lacks any powers of enforcement, resources and the technical capability to assess the environmental impact of major development projects in Bahrain.

B. Egypt

The refining sector was established early in 1954 and completely nationalized in 1966. Petroleum consumption grew at a rapid pace during the decade 1970-1980, and this prompted the adoption of a new policy aimed at rationalizing energy consumption and to improving the efficiency of petroleum production.

The refining capacity of the seven refineries in operation (Ameriyah, Suez I and II, Tanta, Moustored, Asyut and Alexandria) is 23 million tons/year, and there are plans to reach about 39 million tons in 1990. In the last five years, the domestic consumption of various petroleum products has risen at an average annual rate of 14 per cent, while production has increased at less than 7 per cent. Future plans emphasize the need to expand production and refining capacities, and at the same time render the use of domestic energy more efficient.

The petrochemical plant near Alexandria was commissioned in September 1987. The first stage includes the production of 100,000 tons/year of monovinyl choride (MVC), 80,000 tons/year of polyvinyl chloride (PVC) and 160,000 tons/year of chlorine. A second stage is planned for the production of 200,000 tons/year polyethylene.

All refineries are equipped with American Petroleum Institute (API) separators. However, most liquid discharges contain appreciable amounts of pollution, while solid wastes are dumped at random in unauthorized sites. The Egyptian Petroleum Corporation is contemplating installing pollution control equipment in all refineries over the next three years in an effort to alleviate the environmental problems associated with oil refining.

C. Iraq

The State Organization for Oil-Refining and Gas Processing is responsible for the operation of eight refineries (Haditha, Alwand, Al-Multiya, Dora, Basra, Kirkuk, Samawa, Baiji and Qayyarah) with a total refining capacity of 15.5 million tons/year. The two operating liquid petroleum gas (LPG) plants (at Tahji and Zubar) produce 450,000 tons/year, and a third plant planned to produce 1.2 million tons/year. The Zubayr petrochemical complex is designed to produce 130,000 tons/year of ethylene to be used as feedstock for the production of 60,000 tons/year of PVC, 30,000 tons/year of high density polyethylene (HDPE) and 60,000 tons/year of low density polyethylene (LDPE); the commissioning of the plant has been delayed because of the compelling circumstances in the region.

Since the mid-1970s, Iraq has started to give environmental matters some consideration by incorporating environmental protection schemes in its development plans. However, owing to the complexity and diversity of environmental matters and the strong urge to build up the infrastructural base of environmental protection, it will still be some time before environmental matters are fully incorporated into the national development plans of Iraq.

Because of the concentration of oil production and processing in certain locations, the effects of pollution are mainly felt in the areas where oil industries are located. These areas are: Kirkuk, Baiji and Qayyarah in the north, where the main oilfields and refineries are located; Basra, Rumaylah and Az Zubayr in the south, near the main port terminal, and Baghdad where the principal internal market exists. The main gas-processing plants, refineries and two sulphur treatment units currently being expanded are located in the north.

Air pollution problems in the north result from gas flaring, where more than 80 per cent of the gas produced in conjunction with oil recovery is disposed of in this way. This results in the emission of sulphur dioxide, carbon dioxide, particulates and hydrogen sulphide into the atmosphere.

D. Kuwait

Based on the current rate of extraction, the proven reserves of the country will last for another 150 years. In recent years there has been a major shift in Kuwait's oil policy, with emphasis being placed on the marketing of refined products rather than the sale of crude oil. The Kuwait Petroleum Corporation (KPC) was established in 1980 to bring together national companies operating in the field of oil production, processing and transportation into one cohesive corporate structure in order to achieve the optimal development of the oil sector in Kuwait. Among KPCs four companies is the Kuwait National Petroleum Company (KNPC), which is responsible for refining, liquified gas operations and the marketing of petroleum products. KNPC is in charge of three refineries, namely, Ahmadi, Shuaiba and Mina Abd Allah.

The Ahmadi refinery was established in 1949, and its capacity has steadily increased to its current level of 270.000 bbl/day. Other operations that have been added to the refinery in its development include propane and liquified gas recovery, atmospheric residue desulphurization and the production of naphta. The Mina Abd Allah refinery specializes in the processing of high-sulphur crude. In 1968 a hydrogen unit, a heavy gas oil desulphurization unit and a sulphur recovery unit were added. The present capacity of the refinery is 144,000 bbl/day. A modernization plan that includes two atmospheric residue desulphurization units, two delayed coker units, in addition to kerosene and gas oil desulphurization units, is due to be completed soon. This will raise the overall capacity to 200,000 bbl/day.

The Shuaiba refinery is considered to be the first "all hydrogen" refinery to be built in the world. The current capacity of the refinery is 200,000 bbl/day; the main processes include atomospheric and vacuum distillation, hydrogen production, naphtha fractionation, kerosene and diesel oil hydrotreatment, heavy oil hydrocracking, naphtha-platinum reforming, lube oil blending and sulphur recovery.

In addition to the three above-mentioned refineries, the scheme includes a gas liquefaction plant, whereby gases associated with the crude oil that is recovered are compressed, liquefied and fractionated. In 1960, a unit to recover propane and butane gas was established at the Ahmadi refinery in order to meet domestic consumption of these gases. It was later followed by the establishment of two units (producing 65,000 bbl/day) that process the condensate collected from the oilfields. The capacity of these two units was increased later to 80,000 bbl/day. A propane recovery unit was added in 1971, thus increasing the total output of propane and butane gas to 90,000 bbl/day.

In 1979, a gas liquefaction plant (with a capacity of 1,725 million cu ft/day) comprising three trains was established. The liquefaction plant is fed with associated gases, as well as with the condensate separated at the gathering centres of the principal crude oil production zones. The plant is designed to produce 100,000, 55,000 and 40,000 bbl/day of propane, butane and natural gasoline respectively, in addition to 1,150 million cu ft/day of other gases.

All KNPC refineries operate efficient environmental protection schemes. At the Ahmadi refinery the oily wastes are collected and passed through corregated plate intercepters CPI oil separators to reduce the oil to less than 30 mg/l. The separated oil is tranferred to slop tanks and recycled for refining. The waste water is then subjected to treatment in aerated lagoons with a residence time of four days in order to reduce the oil content, H_2S, phenol, chemical oxygen demand (COD) and biochemical oxygen demand (BOD) to the limits discharge values by the action of micro-organisms which feed on organic pollutants in the oily water. The semi-oily water (surface drains, tank roof drains, blow-down drum drains, and decoking water) is discharged to a guard basin so as to separate the oil by skimming. The treated effluent is mixed with the cooling water flow for ultimate discharge into the Gulf. Sour water is fed to strippers after pre-heating to separate the NH_3 and H_2S. The stripped effluent is then cooled and reused as process water or discharged into the sea.

All spent catalysts from the KNPC refineries are now shipped to Japan for reprocessing, while other sludges and solid wastes are dumped in a special area that is operated under the supervision of the pollution control centre of the Shuaiba Area Authority (SAA).

Kuwait has devised a petrochemical industrialization plan for the establishment of an ammonia-based fertilizer industry. The objectives of this plan are to maximize the utilization of natural gas associated with the crude oil that is recovered, and to diversify the sources of national income. In order to effect this plan, the Petrochemical Industries Company (PIC) in Shuaiba was created in 1963 with the aim of using natural gas (considered to be Kuwait's second natural resource) as a feedstock for the production of nitrogenous fertilizers.

In order to meet the rising demands of the international market, PIC implemented a series of expansion programmes, and now produces 990,000 tons/year of ammonia, of which about 65 per cent is in the production of 800,000 tons/year urea. PIC also produces sulphuric acid, chlorine and salt for the local market. The purged gases that accumulate in the synthesis loop (methane, argon, hydrogen and nitrogen) are saturated with ammonia. In the past, gas scrubbing and the discharge of ammonia-saturated effluent caused severe environmental problems, and a net annual loss of 3,600 tons of ammonia. In an effort to solve this problem, PIC has installed a system that recovers 99.5 per cent of the lost ammonia, and the clean washing water is recycled to the scrubber so as to alleviate pollution problems from this source. A new system that recovers urea dust from the prilling towers has also been installed. The process effluent contains about 1 per cent each of urea and ammonia, which renders it unfit for either forestry or disposal into the sea. At present the remaining urea is hydrolyized to NH_3 and CO_2; the effluent is then subjected to stripping so as to reach concentrations of about 60 mg/l each of NH_3 and urea, which then renders it suitable for agricultural purposes. PIC possesses a special monitoring unit for the routine analysis of gaseous and liquid emissions; a full time co-ordinator of environmental affairs is responsible for the planning and implementation of pollution control programmes, in conjunction with the Shuaiba Industrial Area (SIA) pollution control centres and PIC production departments in an effort to ensure adherence to environmental protection regulations.

The heavy concentration of oil-related industries in the Shuaiba area, which stretches some 25 kilometres along the coast south of the city of Kuwait is the main source of industrial pollution in the country. The principal pollutants emitted into the atmosphere are sulphur oxides, hydrogen sulphide, ammonia, nitrogen oxides, carbon oxides and hydrocarbons, while the main water-soluble pollutants are ammonia, urea and inorganic acids.

In view of the environmental pollution in Shuaiba that has resulted from rapid industrialization, and the complex problems associated with its rapidly growing oil industry, the Government is making a determined effort to implement appropriate measures so as to avoid the further deterioration of the environment. A pollution control centre was established in the Shuaiba area in 1968. This centre was recently modernized; it now includes seven major laboratories whose purpose is to monitor pollution levels. Moreover, 18 automatic control networks have been installed in the Shuaiba area, Port Abd Allah and nearby coastline to monitor air, marine and cooling water pollution. These networks measure and record the magnitude of pollution by means of automatic sensors, and report back to a central computer. The results are periodically assessed and reports based on the interpreted data are forwarded to the government agencies concerned. Moreover, in accordance with this interpretation, the centre takes the necessary steps to limit, fight or mitigate pollution.

The pollution control centre, in co-operation with other governmental bodies, also drew up a so-called "code of practice and environmental guidelines" that lays down criteria for the control of gaseous and particulate emissions, the application of water quality standards, together with a base for such criteria (annex I).

Other environmental control methods in the Shuaiba area include preventive planning methods, whereby early site planning and industrial engineering are used in the blueprint stage to minimize pollution. The SAA intervenes to make sure that all land planning for industries, ports, water plants, sewers, cooling water system, etc., is in accordance with proper environmental protection standards. In 1978 the Department of Environmental Protection at the Kuwait Ministry of Public Health adopted strict regulations in order to ensure the appropriate functioning of industrial plants, and their positioning in accordance with specific zoning that takes the nature of the industry and its environmental effects on man into consideration.

E. Qatar

Qatar has proven oil reserves of 33 billion barrels, and proven gas resources of 150 billion cu ft. Industrial development started on a small scale in Qatar in the early 1960s, with the establishment of a few basic industries such as oil-refining and fertilizer production. In the 1970s a more advanced stage of industrial development began at Umm Said, the major industrial complex in the country located on the coast. This complex houses refinery, petrochemicals, fertilizers, iron and steel and cement plants.

In 1968 the National Oil Company was established to refine oil and distribute oil products locally. Successive expansion programmes in the late 1970s has brought the refining capacity up to 12,000 bbl/day. In 1984, in response to the growing deficit between national output and domestic demand, another refinery with a designed capacity of 62,000 bbl/day began operating.

Both refineries are located at Umm Said. The second refinery was built close to the older refinery, and now they are both linked and operated jointly as a single unit. This has decreased operating and maintenance costs. The products of the new refinery include LPG, gas oil, regular and octane gasolines, jet fuel and kerosene.

In 1971 Qatar initiated a large project for the processing and export of natural gas liquid (NGL) that is based on associated gas produced at the onshore Dukhan oilfield. This unit has a daily production capacity of 1,290 tons of propane, 850 tons of butane and 850 tons of condensate in the form of natural gasoline. In addition, the plant has a production capacity of 350 tons/day of ethane-rich gas and four m^3 of methane-rich gas. The ethane-rich gas is used in the nearby petrochemical plant.

Qatar's second NGL plant, commissioned in 1980 is based on associated gas piped to Umm Said on the mainland from the offshore oilfields. It has a daily production capacity of 1,080 tons of propane, 900 tons of butane, 900 tons of ethane-rich gas; production of butane, propane and natural gasoline condensates in both units of the NGL complex, reached 1,430,000 tons in 1984.

Future expansion of NGL production is planned at the North Dome site. Under phase I of the project, an additional dual unit NGL plant capable of processing 22.66 million m^3/day is expected to be employed. Gas products from this plant will be used to supplement industrial and municipal fuel demand in Qatar. Environmental impact assessment (EIA) has been incorporated into the feasibility study of the project.

In 1974, the Qatar Petrochemical Company (QAPCO) was established to manufacture ethylene and LDPE from ethane-rich gas. The designed capacity of the plant is 280,000 tons/year of ethylene, 140,000 tons/year of LDPE and 50,000 tons/year of sulphur. In 1985 QAPCO added a turbo expander unit in order to extract ethane from the feed and produce methane gas. The excess methane is put back into the fuel distribution system.

There are two plants which currently produce ammonia and urea. The total designed capacity of both plants is 590,000 tons/year of ammonia and 660,000 tons/year of urea. In 1985 a gas sweet plant was installed to remove sulphur from offshore gas so as to render the gas more suitable for processing at the fertilizer plant.

Oil refineries and the associated oil-based industries generate appreciable amounts of liquid, air and solid wastes. Estimated loads from the Umm Said complex are as follows:

	Tons/year
1. Airborne emissions	
Sulphur oxides	2,600
Organic compounds	2,800
Nitrogen oxides	2,200
Carbon monoxide	530
Ammonia	277
2. Liquid effluent	
BOD	12
COD	133
Total organic carbon	28
Suspended solids	42
Oil	29
Phenols	0.122
Ammonia	4
3. Solid waste (oily and toxic sludge)	4,717

In addition, the liquid effluent contains a number of organic compounds. The effluent is subjected to physical treatment (decantation) in order to separate the suspended material, which is then collected and ignited; the liquid effluent is discharged into the sea. Cooling water is taken from the sea, and the waste water is discharged into the sea through an open channel on the coast. The solid waste generated at the complex (sulphur, polyethylene, etc.) is dumped inland. Radioisotope Co-60 is used to control the level of polyethylene in the separators. However, no radioactive waste has yet been detected in the environment.

The State's technical and advisory authority in industrial diversification affairs and on major industrial projects is the Industrial Development Technical Centre (IDTC). It was created in 1973 to draw up development plans for the State of Qatar and to supervise the implementation of major industrial projects.

IDTC has been involved in the following activities: (a) the planning of petroleum-based industries; (b) strengthening the inclination of Qatar to take a greater part in the industrialization process; (c) creating and supervising oil-refining and petrochemical companies; (d) implementing industrial integration between the different oil refining/petrochemical fertilizer plants already in existence and proposing the expansion of downstream industries, organizing the exchange of information and experience between local companies and co-ordinating the training of local manpower; and (e) developing plans and executing projects to combat industrial pollution.

In 1981, the Environmental Protection Committee (EPC) of Qatar was established. EPC has power to propose environmental policy and implement plans, draft laws and regulations, manage schemes that offer information, and monitor the quality of the environment. EPC also has the power to withdraw licences from establishments that have been found to contravene regulations. However, EPC has not yet assumed responsibility for monitoring the environment and assessing the environmental effects of major development projects, owing to the lack of specific regulations for most environmental management problems, the vague nature and overlapping of authority of the ministries and agencies engaged in environmentally-related activities, and the shortage of technical and administrative staff to take up these tasks. A joint United Nations Industrial Development Organization/United Nations Development Programme (UNIDO/UNDP) project for industrial pollution control has established a monitoring labaratory at the Umm Said complex; the second phase of the project involves the identification of the sources of pollution and the proposal of control measures. The project is being implemented in conjuntion with IDTC and EPC.

F. Saudi Arabia

Saudi Arabia is the largest oil producer in the ESCWA region. With the recent developments in its oil industry, it possesses the greatest and most advanced capability for oil-processing and its downstream industries. The major oilfields are all located in the eastern part of the Kingdom. The largest are Ghawar, Abqaiq and Sufaynah. The overall production capacity could rise as high as 15 million bbl/day, but the maximum recorded to date was 10.5 million bbl/day in 1980. National gas resources were estimated to be 3,433 billion m^3 in 1983. The development of the oil-based sector is the responsibility of four organizations: the Royal Commission for Jubail and Yanbu (RCJY), the Saudi Basic Industries Corporation (SABIC), the General Petroleum and Minerals Organization (PETROMIN) and the Arabian American Oil Company (ARAMCO).

RCJY is responsible for building the infrastructural facilities in Al Jubail and Yanbu, the two sites respectively selected on the east and west coasts, where basic industrial projects are located. PETROMIN will set up a number of new oil refineries and a cross-country pipeline to supply the Yanbu projects with crude oil. SABIC is preparing and implementing a number of petrochemical and iron and steel projects, in co-operation with several foreign companies that specialize in this field. The industrial plan for Jubail anticipates the establishment of 17 primary, 136 secondary and over 100 tertiary industries by the year 2000.

PETROMIN was established in 1962 and was given responsibility for the implementation and administration of public projects for petroleum and minerals, the importation of the necessary raw materials, the preparation of studies, and the supervision of petroleum and mineral operations such as exploration, production, refining, transportation and distribution.

SABIC, established by royal decree in 1975, was set up to operate and market the products of industries that were based upon local hydrocarbon and mineral resources, together with other downstream and supporting industries.

In 1984 Saudi Arabia's oil-refining capacity was estimated to be about two million bbl/day, produced mainly at ARAMCO's Ras Tannurah refinery which has a capacity of 738,000 bbl/day. Other refining centres are Jedda, Mina Saud, Khafji, Riyadh and the PETROMIN-Shell facility at Al Jubail.

Plans for four major new refineries are being considered and these will add a total of 800,000 bbl/day to the refining capacity. In addition, a number of existing refineries have been expanded and modernized. The first was the Riyadh Refinery which can now produce six million tons/year.

In the western region a refinery with a capacity of 7.7 million tons/year will be build at Yanbu. This will be of the hydroskimming-type that will produce fuel-oil for bunkering services and desalination plants in the area. This project, however, seems to have been postponed for economic and production reasons.

In addition, there are a number of lube oil plants in Riyadh, Jedda and Al Jubail.

The Saudi Arabian Fertilizer Company (SAFCO) produces urea (33,000 tons/year) and sulphuric acid (100,000 tons/year). A new ammonia plant at Al Jubail with a capacity of 1,500 tons/day is being planned by SABIC and SAFCO; it is due to come on stream by the end of 1987. There are plans for the future expansion of the production of nitrogen phosphate potash (NPK) and purified teraphtalic acid (PTA), both used in the manufacture of polyester. In 1984 a 20,000 tons/year melamine plant went into operation at the Dammam complex. The Saudi Methanol Company, located in Al Jubail, was one of the first SABIC plants to start operating; it has a designed capacity of 600,000 tons/year of chemical-grade methanol.

The Al Jubail Fertilizers Company (SAMAD), established in 1979, produces 500,000 tons/year of urea and 330,000 tons/year of ammonia. Production from this plant meets part of the needs of local agriculture. Plans already exist for a new 500,000 tons/year ammonia plant that will cater mainly for the export market.

The Saudi Yanbu Petrochemical Company (YANPET) went into production at the end of 1985. The complex comprises units for the production of 455,000 tons/year of ethylene, 220,000 tons/year of ethylene glycol, 200,000 tons/year of LDPE and 900,000 tons/year of HDPE.

The Al Jubail Petrochemical Company (KEMYA), established in 1980, has a designed capacity of 260,000 tons/year of LDPE. Another petrochemical company based at Al Jubail is the Saudi Petrochemical Company (SADAF). This is the largest SABIC project. SADAF will specialize in the production of ethylene, ethylene dichloride, styrene, ethanol, and caustic soda. A methanol plant with a capacity of 650,000 tons/year is under construction as the National Methanol Company (Ibn-Sina).

The major plants of the Jubail Industrial Complex (JIC) are provided with on-site treatment facilities. Pre-treated effluent is given its final treatment in a conventional activated sludge plant which is followed by rapid sand filtration and ozonization. The estimated flow in 1986 was 60,000

m^3/day while the projected flow for 1999 will be some 125,000 m^3/day. Part of the treated effluent is to be used for irrigation purposes, while the remainder will be discharged into the Gulf. In Yanbu, two centralized waste treatment plants with a total capacity of 36,000 m^3/day will purify the combined effluent for further use in irrigation and landscaping.

In 1980, about 60 per cent of the natural gas produced in the country was flared, and this resulted in an estimated emission of 2 million tons/year of sulphur dioxide. The practice of flaring caused serious air pollution, apart from wasting valuable resources, both of which prompted the Government to establish new industries that would utilize the wasted gases for the production of liquified petroleum gas, urea, methanol, ethylene and other organic chemicals. In practice, this approach is considered to be a method of environmental control. At present three gas plants operating at Berri, Al Uthmaniyah and Shedgun catch most of the sulphur dioxide. According to 1984 estimates, the quantity of sulphur dioxide produced by flaring was reduced to only 0.4 million tons/year.

The amount of hazardous waste generated by JIC was about 32,000 tons/year in 1984; by 1996 it is expected to reach 341,000 tons/year. Hazardous waste consists mainly of inorganic sludges (brine, oily scales, desalter solids from the petrochemical, steel, copper and sulphur industries), organic liquids (oil skimmings, spent monoethanolamine, hydraulic fluids and waste paint) and organic sludges (air flotation sludges, tars, heavy ends and polyethylene benzene). The on-site incineration, transport or disposal of hazardous waste outside the complex is prohibited. A new area in the general sanitary landfill of JIC has been set aside for the interim storage of this waste until such time as a feasibility study for the establishment of a centralized treatment facility that encompasses an incinerator, a sludge de-watering unit and a sanitary landfill has been carried out. In 1982 air emissions from petroleum refineries and their associated facilities were estimated to be as follows: sulphur dioxide 4,692 tons/day, nitrogen oxide 224 tons/day, hydrocarbons 18 tons/day and carbon monoxide 11 tons/day.

Recognizing the need for a systematic approach to counter environmental problems, long-term environmental objectives were incorporated into the Third Development Plan of the Kingdom, and the Meteorological and Environmental Protection Administration (MEPA) was established as the official organ for the organization and co-ordination of environmental protection activities in the country. Environmental protection standards provide an appropriate base for the evaluation and regulation of development activities, including industrial establishments already in existence, and help in the planning, design, execution and operation of new facilities in an effort to ensure the welfare of the people and to promote economic and social well-being, while at the same time they protect the environment and natural resources of the Kingdom. Based on the best available and economically feasible control technology, MEPA source standards have established the emission loads that are permitted to be released by a particular source.

MEPA enforces these standards through a mandatory review and licensing process that permits MEPA's involvement during the design, construction and operation of major industrial projects.

G. United Arab Emirates

Oil constitutes the main source of income for the United Arab Emirates, and most of the industrial expansion currently underway is based on or linked to oil and gas.

The first Umm Al Nar refinery was commissioned in 1976 with a total production capacity of 700,000 tons/year. The second Umm Al Nar refinery started production in 1983 with a capacity of 2.8 million tons/year. Both refineries are of the simple hydroskimming type and produce LPG, gasoline, aviation kerosene, gas oil and fuel oil. Processes at the Umm Al Nar refineries include crude distillation, naphta hydrotreating, kerosene hydrotreating, catalytic reforming, LPG recovery and sour water stripping. Oily waste water from storage tanks draw-offs, oily condensate, equipment drains and rain-water run-off from the operation area are flowed to an overflow diversion structure which regulates the flow to a corrugated plate interceptor (CPI) at a dry weather flow rate of 60 cu hour(h). The recovered oil is recycled for reprocessing, while the treated effluent is combined with the sea water coolant and discharged into the sea. Acid and caustic spills are diluted and neutralized before being discharged into the sea. Effluent contaminated with tetraethyl lead (TEL), composed of residues of TEL, lead gasoline spills, tank sludges and washdown from the TEL area, are treated by oxidation which uses potassium permanganate to convert the organic portion of TEL into its non-hazardous inorganic form. The sour water generated from the processing unit is subjected to stripping in order to remove H_2S, NH_3 and ammonium sulphide, which leaves a sweetened water that can be recycled for use in the crude unit desalter. The stripped gases are either burned in the crude unit heater, or flared. This process reduces the water consumption of the desalter. The ballast water is fed to a titled plate interceptor with dual media pressure filters at flow rate of 260 cubic metres/h. The treated ballast water is discharged if it meets the maximum limits of 15 mg/l oil, 30 mg/l BOD and 30 mg/l suspended solids. If the flow exceeds these limits, an alarm sounds and the "off-specification" ballast water is recycled for further treatment before it is released into the sea.

The Ruways refinery comprises distillation, naptha desulpurization, plate-forming, kerosene hydrotreating, heavy oil desulphurization and sulphur recovery. The plant capacity is 5.2 million tons/year. The processing effluents are treated in two American Petroleum Institute (API) units that each handle a flow of 100 cu m/h. The treated effluent contains a maximum of 50 mg/l of suspended solids and 50 mg/l of oil. This effluent is combined with ballast water and is subjected to mechanical flotation that causes oil separation by inducing air bubbles in the presence of a polyelectrolyte demulsifying agent. The final effluent discharged to the Gulf contains a maximum of 30 mg/l BOD and 15 mg/l oil.

The FERTIL plant of Ruways produces urea (495,000 tons/year) and ammonia (30,000 tons/year); both products are destined for the export market. The waste water stream from FERTIL consist of oily waste (compressor drains, oil wash/rain from processing areas) and chemical waste (process condensates, boiler blow-downs) with high levels of NH_3 and urea. The oily waste water is pre-treated in an oil separator before treatment in an oxidation pond. The aerated effluent is mixed with chemical waste before being subjected to further treatment by neutralization. The neutralized effluent is discharged into the sea with a maximum content of one mg/l of NH^3 and five mg/l of urea. The air from the prill tower contains urea dust. These particles are removed at the top of prill tower. The clean air is discharged into the atmosphere and the water containing urea is reused in the process. The gas discharged from the dust scrubber is intended to contain less than 30 parts per million (ppm) of urea. Although several catalysts are used at the Umm Al Nar and Ruways refineries and fertilizers plant, the spent materials are either shipped for reprocessing abroad or disposed of in controlled landfills.

In addition to the above-mentioned industries, many other energy-intensive and oil-based projects, such as doubling the capacity of the fertilizer plant, new onshore liquefaction projects, a lube-oil plant, an aromatic petrochemical complex, etc., are currently under study. Thus, it will not be long before Abu Dhabi becomes a major centre for the oil industry. These changes are in line with the development priorities of the Government, which call for the establishment of large-scale industries based on oil and natural gas. These industries are bound to put considerable stress on the environment and may expose a large section of the population to new environmental hazards if no appropriate action is taken a priori to control their emissions.

IV. ENVIRONMENTAL EFFECTS OF PETROLEUM PROCESSING

A. Assessing the environmental impact of a petroleum refinery: methodological guidance

All the potential beneficial or detrimental effects of the new refinery must be described. The description of the anticipated impact should include an estimate of its magnitude, its significance and any other relevant information. The steps involved in preparing an EIS for a new refinery are detailed below.

1. Description of the existing environment

(a) Location. Detailed maps should include the nearest roads, railroads, recreation areas, residential and commercial areas, etc. Major features of the area should be identified and accompanied by a brief description of the probable project impact on them.

(b) Soil. A detailed soil survey should be carried out to identify the soil variables, agricultural potential, depth of the water-table and the presence of fragipans or duripans.

(c) Topography. The terrain and slope characteristic should be described, together with the possibility of soil erosion, run-off from developed areas and aesthetic considerations.

(d) Geology. The ability to support large structures, the availability of ground water, effects of accidental land spill, etc..

(e) Water. Information about all water bodies within the site (drainage area, surface area, flow rate): present uses of water bodies, water quality (turbidity, oxygen demand, pH, phosphates, toxic substances, etc.). Special attention should be paid to parameters that occur naturally at the maximum allowable level.

(f) Air. Information about precipitation, prevailing winds, inversions, frequency of storms, extreme high and low temperatures. The description of air quality should include the levels of particulates, sulphur oxides, carbon monoxide, photochemical oxidants and nitrogen oxides. Evidence of previous or present adverse efects on crops and livestock should be mentioned.

(g) Noise. Ambient sound levels can be measured by a sound level meter during busy and quiet periods.

(h) Physical infrastructure. Information about public transport, water supply, sewerage, solid waste management and energy supply systems should be described.

(i) Aesthetic environment. Description of natural landscape, scenic views, historic and archaeological sites.

2. Description of the proposed refinery, pollution sources and control technology

This section must provide detailed information about processing that could affect the environment directly or indirectly.

The following guidelines explain in detail the proposed format for describing the basic features of the projected refinery. The summary should be supplemented diagramatically by a flow chart identifying the major processing operations, pollution sources, control technology and supporting operations such as docking, trans-shipment and storage.

(a) Description of production processes

(i) Description of the major unit operations which make up the process, together with any planned future expansion;

(ii) Approximate material balance of raw materials, product and by-products, together with the estimated peak capacity and proposed operating level;

(iii) Description of intermittent processes such as start up and shut down, testing, decoking, etc;

(iv) Projected date of start-up and operation.

(b) Sources of pollution

(i) Waste water effluent

a. Storage and transportation:

i. Oil from storage tank bottoms;
ii. Tank cleaning operations;
iii. Leaking, spillage;
iv. Salt filters;
v. Intermediate product storage;
vi. Finished product storage;
vii. Ballast waters from tankers.

b. Desalter waste water

c. Crude oil fractionation:

i. Waste water from overhead accumulators;
ii. Oil sampling lines;
iii. Barometric condensers.

d. Cracking:

i. Accumulator waste water;
ii. Waste water from steam strippers.

e. Hydrocarbon rebuilding:

i. Polymerization waste water;
ii. Alkylation waste water;
iii. Overhead accumulator waste water;
iv. Hydrofluoric and alkylation.

f. Waste water resulting from overhead accumulator

g. Fractionation tower bottoms

h. Hydrotreating unit waste water

i. Grease unit waste water

j. Asphalt blowing operations

k. Product finishing:

i. Drying and sweetening operations;
ii. Lubricating oil finishing wastes;
iii. Blending and fininshing operations;
iv. Washing of tankers prior to loading;
v. Tetraethyl lead additive.

l. Auxiliary activities:

i. Hydrogen manufacture process waste;
ii. Utility functions;
iii. Blowdowns from closed-loop recirculating systems.

(ii) Air emissions

a. Storage tanks;
b. Catalyst regeneration units;
c. Pipeline valves and flanges;
d. Pressure relief valves;
e. Pumps and compressors;
f. Compressor engines;
g. Cooling towers;
h. Loading facilities;
i. Waste water separators and process drains;
j. Blow-down systems;
k. Pipeline blind-flange changing;
l. Boilers and process heaters;
m. Vacuum jets;
n. Sampling;
o. Air blowing;
p. Acid treating.

(iii) Processing

a. Crude oil storage, desalter;
b. Catalytic cracking fines;
c. Coker fines;
d. Alkylation spent sludges;
e. Lube-oil spent clay;
f. Drying and sweetening residues;
g. Storage tank bottoms;
h. Slope-oil treatment sludge.

(c) Treatment

(i) API sludge separator;
(ii) Chemical treatment flocculent;
(iii) Flotation scum;
(iv) Biological treatment of sludges.

(d) Miscellaneous wastes

(i) Office waste paper;
(ii) Cafeteria refuse;
(iii) Shipping and receiving waste;
(iv) Boiler plant ashes;
(v) Laboratory waste;
(vi) Plant expansion, demolition;
(vii) Maintenance refuse;

(e) Other effects

(i) Marine terminal and deep-water port facilities

In cases where new or expanded marine terminal and deep-water facilities are involved in the new source proposal, the following information should be included in the environmental impact assessment (EIA).

a. Location in relation to railways, major access roads, towns, and major commercial and residential areas;
b. Visual character;
c. Land ownership;
d. Water supply and other services;
e. Description of the pier structure;
f. Cathodic protection systems.

(ii) Sulphur recovery system

The recovery system should be described with particular attention being paid to tail-gas air emissions.

(iii) Overland pipelines

Information should be provided about location, impediments leak detection systems, emergency shutdown procedures and oil spill contingency plans.

(iv) Proposed measures for pollution control

a. Water reuse

i. Reuse of sour water from catalytic cracker accumulators for make up to crude desalters;

ii. Reuse of high pressure boiler condensate blow-down as make up to low pressure boilers;

iii. Reuse of treated effluent water, if feasible, for fire mains, cooling systems, etc.;

iv. Reuse of contaminated condensate for regeneration of steam;

v. Use of storm water retention ponds for fire water or other low quality uses;

vi. Use of cooling tower blow-down as seal water on high temperature pumps.

b. Water recycling

i. Recirculation of steam condensate as boiler feed water;

ii. Recirculation of cooling water (in lieu of once-through water);

c. Housekeeping

i. Minimizing waste from sampling stations;

ii. Use of vacuum trucks (or other dry methods) for cleaning up oil spills;

iii. Preventive maintenance programme in order to reduce leaks (pump seals, valve stems, etc.);

iv. Segregation of process wastes and other specialized wastes which are better treated individually as low flow, highly concentrated streams;

v. Curbing process units so that spills, washes and oily storm water run-off can be collected separately and recycled and/or specially treated;

vi. Collection vessels provided near units, with frequent checking, cleaning or maintenance;

vii. Specialized handling systems for process turn around wastes (sludges, wash waters, clean up, etc.).

d. <u>Changes in process technology</u>

The following technological alternatives should be assessed:

i. Replacement of barometric condensers (direct contact condensers) with surface condensers (indirect contact condensers or air-fin coolers;

ii. Substitution of air-fin coolers to relieve various cooling water requirements within the process;

iii. Installation of hydrocracking and hydrotreating processes to reduce sulphide and spent caustic loadings in waste water;

iv. Installation of automatic monitoring instrumentation (e.g. total organic carbon (TOC) monitors for early detection of various upset conditions);

v. Increased use of drying, sweetening and finishing procedures that minimize the spent caustics and acids, water washes and filter solids requiring disposal;

vi. Allowance for expansion of the treatment plant in order to meet increased discharge standards that may be instituted;

vii. Capability of the treatment plant to process different kinds of waste water whose composition differs according to the variation in raw materials, product mix parameters, etc.;

viii. Capability of the treatment plant to remove (or to be upgraded to remove) trace substances that may cause a toxic hazard;

ix. Complexity of operation and maintenance operations.

e. <u>Solid waste control</u>

i. Methods by which all solid wastes will be recycled, reused, or disposed of must be identified for all solid wastes;

ii. Handling of oily sludges and spent caustic wastes;

iii. Heavy metal or trace metal leaching problems should also be assessed;

iv. Treatment plant sludges should be described in detail.

f. <u>Cooling towers</u>

i. Evaporative cooling systems

(1) Spray ponds;
(2) Mechanical draft cooling towers;
(3) Atmospheric cooling towers;
(4) Natural draft cooling towers.

ii. Dry cooling systems: these units use heat dissipating air-fins to reject unwanted heat directly into the air.

iii. Wet-dry systems.

g. <u>In-process pre-treatment</u>

i. Neutralization of spent caustic waste water;

ii. Separation of oil from ballast waters, slop-oil recovery systems;

iii. Clarifiers to separate sediments using chemical coagulants, as necessary.

h. <u>On-site treatment of waste water</u>

Special attention should be paid to the following treatment plant-related considerations:

i. Reliability;
ii. Susceptibility to upset by natural storms, toxic matter, etc.;
iii. Margin for process expansion;
iv. Effluent monitoring system.

(f) <u>Control of air emissions</u>

The following measures should be checked for:

(i) <u>Hydrocarbons</u>

a. Floating roof tanks;
b. Manifolding purge lines to recovery system or flare;
c. Use of vapour recovery systems on loading facilities;
d. Good housekeeping;
e. Covered waste treatment plant;
f. Operation of a carbon monoxide boiler;
g. Use of mechanical seals on pumps and compressors.

(ii) Particulates

a. High efficiency mechanical separators;
b. Electrostatic precipitators on catalyst regenerators, and/or power plant stacks;
c. Controlled combustion (smokeless);
d. Maintenance of correct stack temperature;
e. Use of smokeless flames for burning gases;
f. Use of improved incinerators.

(iii) Carbon monoxide

a. Proper furnace and burner design;
b. Carbon monoxide boiler on catalytic cracking and fluid coking units.

(iv) Odours

a. Good housekeeping;
b. Regulation of hydrocarbons and sulphur emissions;
c. Treatment of sour water stream (produced in catalytic crackers, gas processing units and vacuum towers).

(v) Sulphur dioxide

a. De-sulphurization of fuels used in heaters and boilers;
b. Flue gas de-sulfurization;
c. Low-sulphur fuels.

(vi) Nitrogen oxides

a. Combustion control of unproven units;
b. Stack dispersal.

B. Environmental mitigation and monitoring of pollution

The following measures for the mitigation and monitoring of environmental effects should be assessed:

1. Monitoring of construction effects

(a) Night-time construction traffic.

(b) Measures to prevent erosion and to protect water quality (directing run-off to settling ponds before any discharge into water bodies).

(c) Control of an emission by the watering of disturbed areas.

(d) Revegetation of disturbed areas.

(e) Archaeological testing of the site.

(f) Restrictions on and control of noisy construction equipment.

2. Mitigation of transmission line effects

(a) Control of clearing of vegetation.

(b) Minimizing disturbance to stream banks.

(c) Reseeding of disturbed areas.

(d) Preservation of archaeological sites.

(e) Measure to reduce visibility of the line.

3. Pre-operational monitoring

(a) Terrestrial biology (vegetational survey of rare and endangered species).

(b) Aquatic biology (physical description, sampling, taxonomic description of algae and qualitative description of macro-invertebrates.

(c) Hydrology (ground-water quality, level and movement).

(d) Atmospheric (monitoring of air quality).

4. Operational monitoring

Monitoring should be extended for a period of between three to five years from the date the plant began operating in order to assess any changes in the pre-operational environment.

C. Shortcomings of an environmental impact statement (EIS)

(a) Most effects do not have a simple additive impact upon the environment; rather, they have synergistic or multiplicative effects. Chemicals which were considered to be safe in the past are now known to be carcinogenic, mutagenic or teratogenic. The lack of reliability so often experienced in estimating environmental effects casts serious doubts on the adequacy of an EIS. Furthermore, EISs are generally conceived as advocatory documents in which data may be manipulated unintentionally in order to achieve a certain conclusion.

(b) EISs often become defensive documents filled with masses of information in an attempt to provide proof of their thoroughness and reliability. Although in-depth assessment is generally encouraged, it may backfire as the bundle of irrelevant or secondary information may hinder the investigation of environmental effects that ought to be given priority. This is clearly evident in the often perfunctory discussion of alternatives that obstruct an assessment of the ascertainable effects of feasible alternatives.

(c) The inherent delay in preparing and reviewing EISs may lead to unfavourable economic effects owing to the inflationary impact on construction costs. Extensive delay may lead to significant losses that are caused by a reduction of disposable income, the retardation of commercial activities and the decrease in employment opportunities.

(d) An EIS is usually not considered in the early planning stages of industrial development activities, a fact which makes it extremely difficult or even impossible to modify public and private developers' decisions.

(c) Project- or site-specific EISs are usually limited in terms of time, space and scope; they may fail to identify the ecological consequences of all development activities in a specific area. In an effort to overcome these shortcomings, there is a trend towards a reversion to a new concept of "cumulative impact assessment" which embraces the analysis, interpretation and management of the accumulation of effects on the environment that result from a number of individual developments.

V. CASE HISTORIES

A. Environmental planning for a new refinery

Country: Saudi Arabia.

Project: Qasim Refinery.

Site: 35 km north of the city of Buraydah in the north-central region.

Production: (In thousands of barrels per day) gasoline 45.4, jet fuel 23.0, diesel 51.0, CGT fuel 21.5, fuel-oil 1.4, asphalt 13.0 and sulphur 200 tons.

Justification: Refinery needed to meet rising demand from the central region by 1995.

EIA scope: Review of production processes and planned pollution control measures.

Inventory of baseline data on environmental quality at the proposed site.

Selection of design criteria required to meet national environmental standards.

Inventory of the expected types, sources and loads of pollutants (solids, liquids and gases).

Performance of analyses such as air dispersion and noise modelling in order to assess post-operation effects on the environment.

Examination of and assistance with the selection of appropriate pollution control technology.

Field studies

(a) Air quality

(i) Background: Existing major sources of air pollution include a cement plant 15 km south-west, the Unayzah and Qasim power plants about 45 km south and the Buraydah power plant 22 km south-west.

No baseline data available.

Dispersion modelling analysis based on the production capacity of existing sources, fuel characteristics and quantities have been undertaken, together with meteorological data from the region.

(ii) Emision inventory: Sources of crude unit furnaces, hydrocracker reboiler, catalytic reformer reheater, sulphur plant tail gases, asphalt furnace, process flares, power generators and steam boilers.

Calculated emissions of sulphur dioxide (SO_2) 2,426 kg/h, Nitrogen oxides (NO_x) 615 kg/h, carbon monoxide (CO) 34 kg/h. Hydrocarbons (HC) 120 kg/h, particulate matter (PM) 48 kg/h.

All major emissions were within applicable national standards for the source.

Minor emissions of hydrogen sulphide (HS_2), ozone and fluorides; minor loads, especially (H_2S) resulting from thermal oxidization.

Use of oil with low sulphur content from the refinery as a feedstock for the Qasim power plant would reduce the present load of SO_2 by 500 kg/h.

(iii) Dispersion analysis: The United States Environmental Protection Agency (USEPA) industrial source complex model was applied, using 8,000 hourly meteorological data from the region as input, in addition to emission rates from the identified sources.

Model results indicated that ground-level concentrations of air emissions were within national emission standards.

The potential environmental impact of the refinery on the surrounding air quality was expected to be within acceptable limits.

(iv) Emission control: The conversion of H_2S to sulphur in a recovery unit with an estimated efficiency of 95 per cent.

Residual sulphur compounds are to be incinerated to SO_2.

The sulphur content of the fuel for process heater is to be maintained at less than 2.1 per cent so as to conform with national source standards for SO_2.

The amine scrubbing of fuel gas in order to reduce the H_2S concentration to less than 180 ppm.

Combustion units have been designed to limit NO_x emissions.

The burning of ammonia off-gas generated from sour water stripping as a process fuel for the hydrocracker.

Proper maintenance in order to limit fugitive gases.

(b) Waste water

(i) Effect on water bodies: There are no surface water bodies at the site. The utilization of about 450 m^3/h from ground-water sources as process water, and about 100 m^3/h for landscaping. In addition, about 80 m^3/h of the treated effluent will be utilized to supplement landscaping water needs.

(ii) Effluent control: Sources include oily water, stripped sour water, stripped desalter water, rejects from reverse osmosis and cooling tower blow-down, and spent caustic solution.

The removal of oils from the oily water and stripped desalter stream by an API separator and induced air flotations, to be followed by combination with stripped sour effluent for biological treatment and polishing by filtration in multi-media filters. The treated effluent is recycled for make up to the refinery utility water system.

Spent caustic solutions are to be evaporated in a sealed evaporator, while rejects from reverse osmosis and cooling tower blow-down are to be utilized for restricted landscaping.

The sanitary effluent is to be subjected to full treatment that encompasses activated sludge, filtration and chlorination.

The prescribed treatment system should remove most of the water pollutants and conserve water through recycling as a process water for reuse in landscaping.

(c) Solid wastes

(i) Sources: Sludges, API bottoms, biological sludges, contaminated filter media, spent catalysts, miscellaneous waste such as silica, activated carbon, packing rings and contaminated clay.

(ii) Waste control: Containment and disposal in special landfill site lined with a synthetic membrane. Leachate is to be collected and evaporated in an evaporation pond so as to avoid contamination of under-ground water.

The planned control conforms with the criteria for the disposal of hazardous waste, and will have a minimal impact on ground water and on the environment.

(d) Noise pollution

(i) Standards: No national standards are available. ARAMCO noise standards for the operations area (in-plant) and the surrounding area (community noise limits) should be employed.

(ii) Source and model: There is no significant ambient noise.

All sources with high noise levels are assumed to be controlled to less than 90 decibels (dB).

Locations and expected noise levels have been identified from plot plans and scale models.

Noise levels at the boundary limits are expected to range from below 25 up to 43 dB. These levels are within acceptable community noise limits.

(iii) Control: The use of silencers with compressors, attenuating equipment for fixed heaters and thermal/acoustic insulation of noisy piping.

The plant layout has been designed to allow adequate space for critical noise control.

A noise monitoring programme is to be implemented for out-area and in-plant noise monitoring.

(e) EIA conclusion

The sources of pollution were to be adequately abated so as to have a minimal impact on the environment in adjacent communities. In a recent development, the project has been postponed owing to revised downward domestic demand for refined products, and the unexpected drop in oil prices.

B. Environmental impact assessment of a petrochemical plant

Country: Bahrain.

Project: GPIC.

Background: GPIC is a joint venture between the Governments of Bahrain, Saudi Arabia and Kuwait. GPIC produces ammonia and methanol, each with a capacity of 1,000 m^3/day. The initial phase of the project involved reclamation of 600,000 square metres on the eastern coast of Bahrain. Access is by a 1,500 metre causeway, while a second 500 metre service causeway links the GPIC site to the Sitra wharf.

Processing: GPIC uses khuff natural gas (81 per cent methane) as a feedstock in its operations and fuel at an average rate of 95,000 m^3/h; the only other major resource input is sea water, which is supplied at an average of 18,500 m^3/h for cooling and process water. The production of ammonia and methanol involves reaction processes that are carried out at high temperatures and pressures in the presence of catalysts. Most processes require heating, compressing and cooling, which in turn require large inputs of steam and cooling water, as well as considerable heat exchanger systems in order to maximize the energy efficiency. This could cause the cross contamination of cooling water/condensate streams if there is any leakage of the reaction products. Another source of pollution is the purge stream from the recycled gases separated after a synthesis reaction. It contains ammonia and methanol residues, as well as traces of hydrogen, nitrogen, carbon monoxide and carbon dioxide. The ammonia content of the purge gases is virtually eliminated by water scrubbing, which is then followed by cryogenic liquefaction of the purge stream and fractional distillation. The plant requires several catalysts for the various reaction processes; their lifetime before becoming deactivated ranges from 1.5 to 5 years. The catalysts currently in use include zinc oxide, copper oxide, nickel oxide, iron oxide and cobalt/molybdenum.

Location: The main settlements on Sitra Island lie 3 km north-east of the plant; the island also has a number of industrial projects, including aluminium extrusion, cable and plastic pipe fabrication and a small sulphuric acid plant. At the southern end of the island, 4.5 km south-west of GPIC, lie the largest industrial plants in the country, the BAPCO refinery and the Aluminium Bahrain (ALBA) aluminium smelting plant. The surrounding aquatic environment comprises the extensive inter-tidal mudflats and sandbanks from which the GPIC site was reclaimed, the north-western edge of the coral reef which extends south for some 30 to 40 km, and the sub-tidal soft-bottomed grass-bed areas lying lie south of the inter-tidal region.

Meteorology

The area is characterized by high summer temperatures, low precipitation and a relatively high humidity. In May-June, strong noctural inversions occur, while in Janaury-February, weaker but distinctive inversions occur. Neutral air stability prevails for most of the time with conditions becoming more stable during the winter season.

(a) Air emisions

The flue gas emission rate from the stacks, methanol and ammonia reformers, ammonia flaring and condensate stripping is 715 tons/h. It contains SO_2 (250 kg/h), NO_x (220 kg/h) and NH_3 (21 kg/h). The results of the pre-operational study carried out in 1983 indicate that expected emissions are much lower than the EPA standards of SO_2 (80 mg/m^3) and NO_x (100 mg/m^3); the peak concentrations are low, except when stable and very stable atmospheric conditions with low wind speeds prevail. The height of the stacks utilized by the model are adequate for protection of ground level air quality. Abnormal ammonia emissions may result from leaks, though the extent of these is subject to the practices of operation and maintenance during continuous operation of the plant.

(b) Waste-water

Effluents from ammonia processing comprise boiler blow-down (15-20 m^3/h), demineralizer effluent (five to eight m^3/h) and condensate from the separator and coolers (10-25 m^3/h); the effluent from methanol distillation reaches about 10 m^3/h.

(c) Solid wastes

The estimated amount of spent catalysts generated annually is 2,200 tons made up of zinc oxide (55 per cent), copper oxide (30 per cent), nickel oxide (10 per cent), iron oxide (4 per cent) and cobalt/molybdenum (1 per cent).

(d) Noise

The estimated noise limit is around 75 dB, which is within the recognized limit of 80 dB for the petrochemical industry.

(e) Assessment of environmental impact

(i) Assuming an ammonia emission rate of 1 ton/h from the 30 metre stack, ground level ammonia concentration would be about 0.96 mg/m^3 at the nearest settlement (1.5 km) which is less than the detectable level of four mg/m^3; accordingly the installation of a vented ammonia gathering system or an increase in the height of the stack is not justified;

(ii) When mixed with cooling water condensate water will reduce the ammonia concentration to less than a 1.3 mg/l, which will render the effluent non-toxic to fish and other aquatic organisms; however the ammonia could stimulate considerable algal growth. This in turn may cause de-oxygenation in the tidal pools, and this would certainly affect the smaller aquatic species in the discharge area. The BOD load from the methanol plant could de-oxygenate the surface sediment. A previous study indicates that the discharge of cooling water at 45 ^{o}C could cause thermal pollution with a temperature increase of 2 to 4^{o} C in an area 1.5 km from the outfall;

(iii) Solid toxic wastes will not present a problem during the first two to three years of operation. The land disposal facility provided at the Ad Dur site will be utilized for the disposal of hazardous wastes for GPIC and other major industries in Bahrain. Another option is to export the spent catalyst for reprocessing in or outside the region.

(f) Conculsions

(i) The anticipated long-term effects of effluent discharge encompass: (a) the stimulation of algal blooms on the inter-tidal areas south of the site; (b) the possible de-oxygenation of sediments due to the presence of hydrocarbons; and (c) the generation of hydrogen sulphide, especially during the summer time. However, its effects will be limited owing to the favourable wind condition;

(ii) Biological treatment of GPIC effluent is ruled out as an appropriate method for nitrogen removal, owing to the anticipated fluctuation of ammonia concentration and the need for a large de-nitrifying facility. Steam stripping was recommended as a way of reducing the ammonia level in the process waste water to less than 50 mg/l;

(iii) From the noise attenuation assessment, it is unlikely that the nearest settlement will be exposed to levels much higher than the background level of 30-40 dB;

(iv) No gaseous emission problems are expected;

(v) Hazardous wastes should be contained in drums or stored using other appropriate methods before being transferred for recycling or ultimate disposal;

(vi) It seems unlikely that the permanent staff of about 200 would significantly alter the settlement pattern in the area.

C. Management of solid wastes from a major industrial complex

Country: Kuwait.

Location: Shuaiba Industrial Area (SIA).

Project: Alternatives for solid waste management.

Sources: KNPC, The Mina Abd Allah Refinery, the Lube Oil Plant, the Kuwait Oil Company (KOC), PIC, cement, plastics, asbestos, paper, gas and fabricated steel.

Inventory: (In thousands of tons per year) spent catalysts 7.4, oily sludge 53.6, general wastes 8.6, semi-solid wastes 11.5.

1. Management alternatives

(a) Recycling

(i) Catalyst: Concentration and smelting is not economically feasible owing to the generation of relatively small quantities. A land filling option is preferred at this stage.

(ii) Oily sludge: De-watering and use as supplementary fuel.

Production of a refuse-derived fuel or its utilization for compost production. The use for energy production is not advisable owing to the abudance of natural sources of energy, but compost production could be feasible if it was used in an extended agricultural scheme.

(b) Pre-treatment

The de-watering of semi-solid wastes and the pressing of asbestos slurry into cakes for disposal in a restricted landfill.

Chemical treatment. Caustic and acidic wastes should be mixed for neutralization.

(c) Land disposal

The land application of oily wastes is a proven technique that could be applied in SIA.

A landfill could be environmentally safe if the leachate is controlled. About 170,000 tons/year of solid waste from SIA could be disposed of by this method.

(d) Sea disposal

Disposal at sea should be limited to brine solutions, neutralized effluents and effluents produced by de-watering.

(e) Environmental considerations

Some materials give a greater cause for environmental concern than others. The degree of hazard involved should be determined on the basis of toxicity, reactivity, corrosiveness and flammability of the waste under consideration.

A disposal scheme should be selected bearing in mind the tropical nature of the receiving environment in the region.

Attention should be paid to the additional waste load derived from the improved management of liquid and gas emissions. These could include biological sludges, oily residues and recovered particulate matter.

In-plant controls and water recycling could cause the additional generation of solid wastes.

(f) Selected scheme

The disposal at sea of brine and mixed basic/acidic wastes.

The land farming of oily and other organic wastes.

The pre-treatment of large articles by crushing and mixing with general solid wastes for ultimate landfilling.

(g) EIA conclusion

A comprehensive EIA that addresses the following subjects is already underway:

(i) The type and quantity of future solid wastes;

(ii) Monitoring of the management scheme;

(iii) A cost-benefit analysis of the priority management schemes;

(iv) The impact of heavy metals, especially the potential contamination of ground-water resources;

(v) Agricultural applications and their effects on soil conditions.

D. Impact of industrial pollution on marine environment

Country: Qatar.

Location: Umm Said industrial complex.

Background: The Gulf receives most of the industrial emissions from Qatar as well as those from adjoining States. The jettisoning of rubbish and ballast water from shipping represents another major source of pollution in the Gulf. The Gulf is a semi-enclosed sea with very shallow water, high temperatures and a limited fresh water input, especially in the vicinity of Qatar. The present discharges threaten aquatic organisms, coral reefs and the amenities of coastal communities. The complex houses the following industries: the Qatar Petrochemical Company (QAPCO) National Oil Distribution Company (NODCO), Qatar Fertilizer Company (QAFCO), Natural Gas Liquid Company (NGL), Qatar Steel Company (QASCO) and flour mills.

(a) Waste water

NODCO process streams are subjected to equalization, which is followed by oil separation in an API oil separator. The de-oiled water is then pumped to a biological treatment unit, and this is followed by clarification. The clarified water is polished in a sand-anthracite filter, and is then conveyed to a carbon filter in order to remove the last traces of dissolved organic material. The treated water which contain less than two mg/l oil and 10 mg/l BOD is recycled in order to desalt the crude oil. QAPCO oily water from steam cracking is subjected to de-oiling before being discharged into the Gulf, while skimmed oil, sludges and spent filter residues (activated charcoal) are incinerated in a special incineration unit at the plant. The cooling water and industrial water systems at QASCO are completely separated, as in NODCO and QAPCO. The cooling water can cause thermal pollution dust. There is temperature gradient of 7 to 10° C. All process waters are currently recycled in a closed circuit. The once-through cooling water from QAFCO (50,000 m^3/h) has a temperature gradient of up to 10° C. Minor amounts of waste water from ion exchange and boiler blow-down are discharged directly into the Gulf.

(b) Gaseous emissions

The urea dust discharged from the prill towers represents emmissions QAFCOs major source of air pollution; ammonia is released in minor amounts while the H_2S removed from natural gas is flared with the emission of SO_2. As the plant handles most of the flammable gases under pressure, many processing facilities are equipped to ensure the safe discharge of vented gases in case the need for depressurizing arise. The major sources of air pollution at NGL are SO_2, H_2S and hydrocarbons. In an emergency situation, the oil-based industries at Umm Said are forced to release large amounts of gas into the flare stacks. Though such emergencies are rare, the released gases may cause severe pollution problems.

(c) Solid wastes

Most solid wastes (except those emanating from QASCO) are currently discharged into a nearby municipal pit. Catalysts are partially regenerated on-site or are shipped for reprocessing abroad.

(d) Pollution monitoring

Except for the in-house monitoring of pollution conducted by NODCO for its own emissions, no regular monitoring of industrial pollution is at present carried out either by other plants or by the environmental laboratories of EPC at Umm Said. The EPC laboratory that was previously managed by IDTC is adequately equipped. However, the shortage of chemists and technicians does not permit the regular monitoring of emission sources at the complex.

(e) Outline for environmental survey

The initial phase may involve: (i) an assessment of the sources and loads of pollutants from all industrial establishments at Umm Said; (ii) the chemical and physical characterization of marine quality; (iii) the collection of oceanographic and meteorological data; and (iv) an ecological study of the diversity and abundance of species. This initial phase will help to identify problems, establish the appropriate sampling and analytical techniques, the determinants for routine analysis and the scope of the database.

(f) Proposed survey components

(i) Industrial effluents

a. QAFCO (temperature, pH, BOD, TOC, total solids (TS) suspended solids (SS), settleable solids (Set S), HN_3, diethonalamine, nitrite, urea, surfactants and trace metals). Information on the use of, and fate of, special chemicals such as di-isoproponolamine, morpholine, paraformaldehyde and other toxic substances;

b. QAPCO (temperature, pH, turbidity, BOD, TOC, oils, NH_3, NO_3, PO_4, chlorides and trace metals). A study on reducing sulphur and polyethylene granule emissions and on the use and fate of morpholine, methanol, diethanolamine, dimethyl silicon and the other chemicals used as initiators and catalysts in processing;

c. NODCO (temperature, pH, oil, BOD, TOC, chlorides and trace metals). A study on the proper methods for the disposal of sludges and spent catalysts.

(ii) Marine quality

a. Physical: temperature, salinity, dissolved gases, depth, turbidity;

b. Chemical: conductivity, pH, alkalinity nutrients, micronutrients, priority pollutants and chlorophyll;

c. Biological: plankton, diversity, bacterial counts, fish population and benthic/littoral diversity and abundance;

d. Pollutants: heavy metals, dissolved and suspended oils, organic micropollutants, BOD, chlorinated hydrocarbons and surfactants.

(g) Institutional considerations

EPC is the government organ invested with authority to issue environmental regulations and to implement nation-wide monitoring programmes. EPC needs to strengthen its activities in the management of industrial pollution. The proposed priority tasks include: (i) upgrading the operational capability of the Umm Said environmental laboratory; (ii) establishing criteria and interim standards for industrial emissions, in co-operation with IDTC and the industries concerned; (iv) recommending guidelines for industrial environmental impact assessment (IEIA) and developing an in-house capability for the review and follow-up of IEIA recommendation during the design, construction and start up of new industrial activities and the expansion and modification of existing industries; (v) acquiring the technical capability to extend advice to industrial management on the appropriate methods for in-plant control, end-of-pipe treatment and low and non-waste technology; and (vi) the initiation of an EIA study and the establishment of a monitoring and analytic programme aimed at protecting the marine environment in Qatar, for while a number of preliminary studies recently carried out do not indicate any serious marine pollution problems, the planned construction of the new north gas oilfield, and the envisaged expansion in the oil-based industries may have negative effects on the aquatic environment.

ANNEX I

ENVIRONMENTAL QUALITY CRITERIA FOR THE SHUAIBA INDUSTRIAL AREA IN KUWAIT: AMBIENT QUALITY CRITERIA FOR THE CONTROL OF EMISSIONS

1. Gaseous emissions

(a) The fundamental purpose of air pollution planning and control is the achievement of an acceptable level of air quality. Despite the difficulties involved in relating ground level concentrations of pollutants to emissions, especially on a short-term basis (e.g hourly), any emission control must give prime concern to air quality.

(b) For this fundamental reason, the primary criteria adopted by SIA for the control of emissions to the atmosphere are, where possible, guidelines laid down in terms of ambient air quality.

(c) The distinction between the control of emissions to the air and the control of air quality is one of cause and effect. These are linked together by transport through and dispersion into the atmosphere, which are controlled by the local climate and meteorology.

(d) The relationship between the source emission loads from a proposed development must be viewed in terms of the resultant ambient air quality of the whole area, taking into account any existing operations and future plans. This is generally complex, and is a function of the magnitude and mode of the discharge, the relative location of emission sources, local topography, climate and meteorology. The ultimate responsibility for making this assessment on behalf of the working community at Shuaiba and the nearby residential centres, rests with the authority.

(e) In order to achieve ambient air quality objectives, a proposed action should be provided with the best practicable means of preventing the escape of noxious or offensive gases and smoke, grit and dust into the atmosphere, and where they are discharged through necessity, of rendering such emissions, harmless and inoffensive.

(f) In all cases, the mode of discharge needs to be considered in conjunction with the mass emission rates of pollutant loads.

(g) The ambient air quality criteria for major pollutants is shown in table 1 in terms of the following: the community maximum allowable concentration (CMAC), the community normal maximum concentration (CNMC, 98 per cent) and long-term average concentration (LTAC). All quantities are based on a one-hour sampling time, LTAC being the annual mean of hourly samples.

(h) The ambient air quality criteria for specific aliphatic, alicyclic and aromatic organic substances, both saturated and unsaturated that can occur during crude oil refining and petrochemical processes are not listed individually. These substances are mainly of concern to hygienists and should be safely contained within the plant boundary or discharged in trace quantities only into the atmosphere.

As a guiding principle, these substances should never be detectable anywhere outside the plant's boundary in concentrations that exceed one tenth of the threshold limit value for a one-hour sampling period.

2. Particulate emissions

(a) The adverse effects of particulates derived from industrial plants and associated activities at Shuaiba are more difficult to identify and define than is the case with gaseous pollutants.

(b) There is a complex interaction between airborne, industrially-derived, particulated and naturally-occurring, background dusts. The latter could have been generated locally at Shuaiba or transported from distant sources. The nature and extent of the interaction is governed by both synoptic and local weather conditions.

(c) The primary effects of dust and particulates (including smoke), and secondary nuisance effects, influence not just physiological and psychological health and well-being but greatly contribute to industrial hazards. These problems can be aggravated by the combined effects of particulates in conjunction with gaseous pollutants, particularly under the humid conditions which can prevail in Kuwait during certain seasons.

(d) The overriding concern of the authority to control particulate emissions is to safeguard electrical supplies (and hence supplies of distilled water). The risk of interruption to switchyard operations that can be caused by the effects of corrosion and possible flash-over must be minimised and controlled within acceptable limits.

(e) For these reasons, the primary criteria adopted by the authority for the control of particulate emissions from industrial plants will necessarily be in terms of emission content conditions, imposed as an integral part of the conditions of lease.

(f) Therefore, proposed industries and associated plants and activities must incorporate the best practicable means to minimize and control particulate emissions at source. Evaluation of the proposed equipment and operating procedures is made by the authority.

(g) As a guideline, currently accepted international emission standards for particulates are presented in table 2. It is stressed that these should not be viewed as rigid standards, but only as a guideline for the best practicable application in the Shuaiba Industrial Area.

Table 1. <u>Gaseous emissions: criteria for industrial sources</u>

Substance	Threshold value (TLV) (ppm)	Primary criteria CMAC (ppm)	Primary criteria CMMC (98 per centile) (ppm)	Secondary criteria LTAC (annual mean)
Ammonia	50	2.50	0.800	0.130
Carbon monoxide	50	35.00	10.000	2.000
Chlorine	1	0.10	0.030	-
Hydrogen sulphide	20	0.10	0.030	-
Total mercaptans		0.05	0.017	-
Nitrogen oxide	5	0.50	0.170	0.025
Oxident (as ozone)		0.06	0.020	-
Sulphur oxides	5	0.50	0.170	0.025
HCL (hydrogen chloride)	5			

Table 2. <u>Tentative particulate emission criteria for new plant</u>

Substance	Source of emission	Emission criteria (Mg/m^3 - STP)
Cement dust	Cement grinding and crushing	100
Heavy metals, e.g. antimony, cadmium, lead, mercury	As for the element	23
Sulphuric acid	Sulphuric acid plant	230
Total solid particulate matter		
Dust and grit larger than 10 um	Miscellaneous; incinerators, cupolas, process furnaces and heater sintering plant.	460
Fines, fumes, less than 10 um		115
Urea	Plant fertilizer plant	130

3. Basis of criteria for the control of emissions released into the atmosphere

(a) Criteria were adopted that would place limits on the magnitude and frequency of the higher ambient concentrations of airborne pollutants that are a cause for concern for the authority. The most important reasons for these controls are to protect human health and well-being in the broadest sense, in accordance with the World Health Organization (WHO) definition:

> "Health is a state of complete physical, mental and social well-being and not merely an absence of disease and infirmity".

(b) Exposure to chemical substances in concentrations greater than those present naturally, may or may not affect the average healthy adult. If the concentration of a specific substance is sufficient, when it is present on a continuous or intermittent basis, it can produce pronounced physiological effects, so the consequences of increased or even continued exposure must be carefully assessed. Even healthy people in the prime of life may be adversely affected by continued exposure to sub-critical concentrations of certain substances. It must also be borne in mind that it may take years of continued exposure before the physiological effects become apparent, by which time it may be too late to take remedial action, at least as far as those already affected are concerned.

(c) Thus in this context, two effects of air pollution should be discerned.

(i) Acute effects. This term is used in relation to the effects of certain concentrations of air pollutants that produce a response that comes to a rapid climax. Generally, these are caused by short-term exposure to high doses.

(ii) Chronic effects. This term refers to the lasting damage or effects of air pollution that are generally caused by repeated exposure. These effects may be more subtle or indirect, and hence much more difficult to detect.

(d) Controls to protect against the air pollution problems at Shuaiba have been made more complex by the potential presence of many chemically active species in the ambient atmosphere. Thus, criteria have had to be adopted with a view to safe-guarding the community against the effects of pollutants acting in conjunction with each other, as well as individually.

(e) For the purposes of planning and control, the term "community" refers to all areas outside the boundary fence of a proposed industrial development, where there is a probability of exposure covering a wide spectrum of people who may not be healthy and fit. Community areas therefore include neighbouring industries, roads and buildings that could be several storeys high, or at ground level.

(f) Thus, the management of proposed industrial development must ensure that, whatever the type of emission, either by design, accident, or by other cause, the concentration of such substances must be rendered safe by processing and dilution, before they are transported up to or beyond the boundary fence, where the public can be found.

(g) Any limits on the protection of the community have to be defined to include not only concentration, but also the time subject to exposure. When monitoring to confirm that criteria are not being exceeded, the "time of exposure" is synonymous with sampling period. The time basis of the adopted criteria is a one-hour sampling time. This basis satisfies the general requirements that the sampling period should be compatible with:

(i) Acute physiological response;
(ii) The persistence period of prevailing meteoroglogical conditions;
(iii) The distance of the fetch between source and receptors;
(iv) The technology for monitoring.

(h) When considering the effects of pollutants on the environment, and on human health in particular, it is the frequency and magnitude of high concentrations that are of importance, rather than a long-term mean concentration. Whilst the mean value of a pollutant, at a particular location must be independent of sampling time, the higher values will decrease with longer sampling times.

(i) The primary air quality criteria for Shuaiba are defined as follows:

(i) <u>CMAC</u>: This is the inviolate level of a pollutant that should never be exceeded outside the site boundary of an industry in any sample collected over a period of one hour. This value <u>must not be regarded as a routine maximum</u> allowable concentration, but as an absolute level above which the most urgent action is required by the polluting industry to rectify the condition;

(ii) <u>Community normal maximum concentration (CNMC)</u>: This is the ambient concentration of a pollutant that can only be exceeded on 2 per cent of occasions over a one-hour sampling period. In general, the magnitude of this parameter is given by:

$$CNMC = 1/3\ CMAC$$

Any pollutant concentration that exceeds the CNM level is therefore an indicator for alert and investigation.

(j) As a secondary air quality criterion, the LTAC of each pollutant is specified for the Shuaiba area. This represents the level below which action to reduce concentrations of pollutants further would not be generally justified.

In general the relation between the primary and secondary criteria are given by:

$$CMAC = 20\ LTAC$$
$$CNMC = 6.7\ LTAC$$

(k) The CMAC value of any gaseous substance can be related to its TLV by the application of an appropriate excursion factor to account for an hour long exposure by sensitive members of the community.

Unless there is overriding medical evidence, an excursion factor of 10 has been adopted by the authority, yielding the relationship:

$$CMAC = TLV/10$$

The TLV is the universally recognised concentration of an individual pollutant recommended by the American Conference of Governmental Hygienists as the maximum level to which healthy adult workers can be exposed during the course of a normal working week (8 hours/day, 5 days/week).

2. Summary of the application of water quality criteria to waste waters discharged to the water of the Gulf

(a) The designation of the Shuaiba inshore waters as a sea-water reservoir requires that measures be taken to restore and conserve the condition of the sea water at this location.

(b) These criteria, as applied to industrial liquid effluents, should be used to determine the total mass load of any pollutant that could be discharged in a given time into the specified environment, in this case the Shuaiba marine environment.

(c) The criteria for the discharge of liquid effluents into the Arabian Gulf at Shuaiba, Kuwait, are summarized in table 3.

(d) The criteria reported in table 3 are partially derived from the results of bioassays that determine the biological response to a single chemical species present in otherwise pure sea water. The presence of several chemical species in sea water can introduce a cumulative biostress factor, in that the presence of one material reduces the tolerance of the organism to the other chemical species present. This phenomenon should be considered when applying criteria to marine environments containing several pollutants, as the desirable environmental value (DEV) and the threshold hazard value (THV) may have to be reduced. This cumulative stress effect is not the same as a synergistic effect which, when known, can be incorporated into the criteria.

(e) The terminology of the chemical compounds and species listed in table 3 is consistant with normal international usage.

(f) It should be noted that thermal effects are not included in these criteria, and these are based on the normal environmental value expected at the particular location. An increase in the temperature and thermal stratification of the water column (reducing transport processes) can reduce the levels present.

(g) Certain types of marine life are known to accumulate substances (A), (c.f., table 3) within their body tissues to such an extent that they become unfit for human consumption. Thus, seafood should not be harvested for

Table 3. Recommended ambient marine environment quality criteria for inshore waters around Shuaiba

Parameter	I Desirable environmental value (DEV) (ppm)	II Maximum/minimum threshold hazard value (THV) (ppm)	III Reference discharge load tonnes/day from total industrial unpolluted sea water collant.
pH	8.0	5.5 to 9.0	-
Dissovled oxygen	5.4	2.0	-
COD	2.0	4.0	15.0 dependent on receiving waters
BOD	2.0	4.0 ppm	
Total hydrocarbon (A/B)	Not detectable	(as in water bulk)	0
Phenolics (A/B)	0.05	0.10	0.25
Detergents (B)	0.05	0.20	0.25
Sulphides (H_2)	0.005	0.01 (as suphide ion)	0.025
Ammoniacal Nitrogen (NH_3/(NH_4)	0.02	0.20 to 0.50 (as ammonium ion)	0.025 Total nitrogenous lead 2.75
Oxidized nitrogen	0.40	0.80	
Total nitrogen	0.50	1.30	
Inorganic phosphates	0.001	0.02	0.005 to 0.10
Cyanide	Not detectable	0.01	0
Alkyl Mercury (A)	-do-	0.0001	0
Total Mercury (A)	-do-	0.0001	0
Arsenic (A)	0.01	0.05	0.05
Cadmium (A/C)	0.0001 to 0.01	0.03	0.005
Lead (A)	0.01	0.05	0.05
Chromium (A)	0.05	0.10	0.25
Copper (A/C)	0.001 to 0.01	0.05	0.005
Zinc (A/C)	0.001 to 0.05	0.10	0.005
Iron	0.05	0.30	0.25
Manganese (A)	0.02	0.10	0.10
Nickel (A)	0.002	0.10	0.010
Coliform bacteria (A)	100 MPN/ml	2000 MPC/ml	-

human consumption from this area, particularly under conditions prevailing in column II of table 3, unless adequate checks are maintained by the public health authorities in accordance with recognised (e.g. WHO) food criteria, adjusted to the local seafood consumption demand.

(h) Certain compounds (B) in table 3 are known to cause the tainting of fish flesh, which though it may be within health standards, would not be palatably acceptable, and hence would have adverse implications for the fishing industry.

(i) There is evidence to indicate a synergistic increase in the toxicity to life of certain metals (c) (c.f. table 3) when these are simultaneously present in the aqueous environment, and a recommendation has been made that the total combined concentration of these metals should be no more than 0.10 mg/l.

(j) Extreme care should be taken over using water from a marine environment in conjunction with conditions that are above the hazard threshold value for public purposes, as allowance has not been made in table 3 for particulate concentration factors (e.g. sediments and detritus).

(k) The resultant, or final liquid effluent, that leaves any industrial site at Shuaiba for discharge into the Gulf should have a quality not materially worse than that implied by column (I) of table 3, and should not exceed the values given in column (II), THV. This restriction would not necessarily apply to the disposal of liquids in an off-site treatment plant.

(l) Thermal pollution caused by the discharge of sea-water coolant has for the present been tolerated. However, the temperature effects need to be mitigated by the correct design of the liquid effluent outfall and on no account must the discharge increase the bulk ambient water temperature of the inshore waters at Shuaiba by more than 2^{o} C. The exact conditions will depend on each application.

(m) The total maximum sea-water coolant effluent, discharged from all the industries in the Shuaiba Industrial Area, is at present of the order of 5.5 x 10 metric tonnes per day. This mass flow rate can be used to assess the total allowable mass discharge of pollutants from all the industries in the Shuaiba Industrial Area on a daily basis, and not the discharge from each individual industrial site, as this water is returned to the Gulf. The mass discharge rates for each pollutant at DEV are given in column (III) of table 3. An equivalent calculation can be made for THV discharge rates. The proportion of this total mass rate of discharge of any pollutant attributable to each industrial site is equivalent to that fraction of the total sea-water coolant used on the industrial site.

(n) If DEV mass loading is exceeded, and this load includes those components already present in the sea water, then undersirable polluting conditions would be initiated. If THV mass loading is exceeded then conditions that would be hazardous to a balanced marine environment will be initiated.

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