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The Energy Sector's Environmental Impacts on Water Resources and the Relevant Regulations and Standards

THE ENERGY SECTOR'S ENVIRONMENTAL IMPACTS ON WATER RESOURCES AND THE RELEVANT REGULATIONS AND STANDARDS

CONTENTS

ABBREVIATIONS

API	The American Petroleum Institute
BOD	Biochemical Oxygen Demand
CAA	Clear Air Act
COD	Chemical Oxygen Demand
CWA	Clean Water Act
EEC	Former European Economic Commission
ER	Executive Regulations
ESCWA-MS	ESCWA member States
EU	European Union
IPPC	Integrated Pollution Prevention and Control
Mb/day	Million barrels per day
Mw	Megawatt
NG	Natural Gas
OPA	Oil Pollution Act
PURPA	Public Utility Regulatory Policies Act
SDWA	Safe Drinking Water Act
TOC	Total Organic Carbon
USA	United States of America

THE ENERGY SECTOR'S ENVIRONMENTAL IMPACTS ON WATER RESOURCES AND THE RELEVANT REGULATIONS AND STANDARDS

Introduction

In spite of the vital importance of the energy sector for the economic and social development in the ESCWA region, however all energy cycles are sources of serious environmental impacts that threaten human health and welfare. Such impacts are along many stages of the energy cycle starting from the extraction to the end-use in different economic sectors and it affects most of the natural resources, particularly air, water and soil resources. [1]

The environmental impacts of the energy sector on water resources are crucial and vary much from one country to the other in accordance with: (1) The structure of the energy sector; (2) the type and size of the facilities which determine its water requirements; and (3) the type and concentration of liquid effluent discharges to the aquatic environment.

The ESCWA energy sector has some characteristics which affect the type and depth of its impacts on the water resources. It include: (1) **A huge Oil and Gas subsector**, with remarkable impacts on the marine environment, ground water and possibly surface water resources; (2) **A large Electric Power Sector** which is dominated by thermal electric generation discharging large volumes of waste-water to the available water stream; (3) **Hydro power plants** are built and operated in some countries in the region with all its known environmental impacts on the river streams; and (4) **The energy end-use sectors**, particularly industry discharging contaminated wastewater.

This paper presents an assessment of the environmental impacts of the two main energy production subsectors on water resources and the relevant environmental regulations and standards. These are namely: (1) The Oil and Gas Sector; and (2) The Electric power sector. The impacts of the industrial sector are mainly due to liquid effluent discharges to water resources which is similar to that of the electric power sector, however in a different scale.

I. THE ENVIRONMENTAL IMPACTS OF THE ENERGY SECTOR ON WATER RESOURCES

There is a wide variety of environmental impacts on water resources that are caused by the activities of the energy sector. It vary much based on the type of energy resources, type and volume of activity, as well as the nature of the subject water resource. This part overviews the possible environmental impacts on water resources by both Oil and Gas and Electric Power Sector.

A. THE ENVIRONMENTAL IMPACTS OF THE OIL AND GAS SECTOR ON WATER RESOURCES

The oil and gas sector has considerable environmental impacts, which are likely to occur during exploration, production, transport, refining and distribution. These impacts can affect water and marine resources and include the risks of major environmental accidents. The potential environmental impacts of the different Oil and Gas activities that are relevant to the water sector are summarized hereinafter.[2]

(b) **Impacts of Oil and Gas transportation.** Offshore, near-shore, and upland, Oil and Gas pipelines have different environmental impacts, depending on the type and size of pipeline installed. The pipeline can also result in a resuspension of these toxic sediments, temporarily lower water quality immediately, accidental ruptures to pipelines, and oil spills can affect the marine water quality.

B. Environmental Impacts of the Electric Power Sector on Water Resources

The ESCWA electric power sector has developed tremendously during the last two decades. The installed capacity reached 71613 MW in 1997 out of which 65164 MW are thermal generating plants, while hydro-power station counted only for 640 MW.

The following is a brief description of the environmental impacts on water resources of the Electric Power Sector classified by type of generation and the category of impacts of each. [3]

1. Impacts of thermoelectric projects

The type of facility and size of thermoelectric projects, as well as its location will determine the type and level of associated environmental impacts. Different impacts on water resources can occur both during construction and operation of thermoelectric plants including:

(a) **Large wastewater streams** discharged from thermoelectric plants are typically rather clean cooling water, which can be either recycled or discharged to a surface water body with minimal effects on chemical quality, however the impacts of waste heat on ambient water temperature need to be considered. If once-through cooling is being considered, heated water discharges can radically alter aquatic plant and animal communities;

(b) **Oil spills** oil-fired facilities have a negative impact on water quality. In addition, changes in surface water and ground water quality can be caused by thermal power plants.

It is to be noted that a number of impacts can be avoided or mitigated by prudent site selection. In addition, standards for the quality of wastewater from thermal power plants should be strict and relevant to the conditions of the water stream it is discharged in.

2. Impacts of hydroelectric projects

Hydroelectric projects include dams, reservoirs, canals, penstocks, powerhouses, and switchyards for the generated electricity. Hydroelectric reservoirs may be multi-purpose and can provide one or more of the following services: irrigation, flood control, water supply, recreation, fisheries, navigation and sediment control. However, these are competing uses for the waters stored behind dams and each may imply a different diurnal or annual operating rule curve for the reservoir.

The principal source of impacts in a hydroelectric project is the construction and operation of a dam and reservoir. Large dam projects cause irreversible environmental changes over a wide geographic area and thus have the potential for significant both negative and positive impacts, as described below:

(a) While there are direct environmental impacts associated with the construction of the dam (e.g., dust, erosion, borrow and disposal problems), the greatest impacts result from the impoundment of water, flooding of land to form the reservoir, and alteration of water flow downstream. These effects have direct impacts on soils, vegetation, wildlife and wildlands, fisheries and climate.

(b) The dam's indirect effects include those associated with the building, maintenance and functioning of the dam, including deterioration of water quality in reservoir, formation of sediment deposits creating

4. Integrated Pollution Prevention and Control (IPPC)

Integrated Pollution Prevention and Control (IPPC), regulation has been enforced in lately in some developed countries to ensure integrated protection of environment and avoid the fragmentation of standards. The goal of the IPPC is to achieve integrated prevention and control of pollution arising from a wide range of activities by means of measures to prevent or, where that is not practicable, to reduce emissions from industrial facilities to air, water and land, in order to achieve a high level of protection of the environment as a whole.

In view of the above classification, the major water environmental regulations and standards that are relevant to the energy sector would be mainly:

- **Primary Water Ambient Quality Standards**, defining the permissible maximum allowable levels of pollutants in the water;
- **Performance Standards** specifies the requirements and specifications of the wastewater discharges to water streams;
- **Practice Standards** which prohibit the discharge of wastewater for specific environments (coastal areas) or limitations in the use of produced waters for enhanced oil recovery ... etc.

B. THE ENVIRONMENTAL REGULATIONS AND STANDARDS FOR THE OIL AND GAS SECTOR RELEVANT TO WATER RESOURCES

Historically, the oil and gas industry has played a leading role in developing environmental regulations and standards. The following describes some of the available environmental regulatory programmes and standards relevant to the protection of water resources in the oil and gas subsector in USA, Europe and ESCWA member States. The cases of both USA and EU can be taken as lead examples for ESCWA member States in developing their national and regional standards for the different energy sub-sectors:

1. The Case of the United States of America (USA)

The oil and gas exploration and production industry in the USA had regulated the industry's impact on the environment for decades prior to federal regulation. Such regulations and standards are subject to consequent amendments resulting from different concerns faced by the sector. Since the 1970s the US federal government has issued several environmental statutes and regulations in many areas. The following is a brief on the major environmental legislation that regulates the oil and gas industrial impacts on water resources in the United States: [5]

(a) **The Oil Pollution Act (OPA)**, of 1990 streamlined and strengthened the USA Environmental Protection Agency EPA's ability to prevent and respond to catastrophic oil spills. A trust fund financed by a tax on oil is available to clean up spills when the responsible party is incapable or unwilling to do so. The OPA requires oil storage facilities and vessels to submit to the Federal government plans detailing how they will respond to large discharges. EPA has published regulations for aboveground storage facilities; and oil tankers. The OPA also requires the development of Area Contingency Plans to prepare and plan for oil spill response on a regional scale.

(b) **The Clean Water Act (CWA)**, is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. The basic underlying purpose of the Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The law gave EPA the authority to set effluent standards on an industry basis (technology-based) and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person to discharge any pollutant from a point source

(i) **In EGYPT,** at least 10 major national laws governing water quality, quantity, and use have been enacted since the mid 1960's, and they are considerably more profuse and complex than other laws. In 1994, Egyptian Law for the Environment (Law Number 4) has been ratified and promulgated. In the First Article of the Law it is stated: "Along with compliance to the regulations and provisions mentioned in the special laws, provisions of the attached law shall apply to the environment. Establishments existing at the time of promulgating this law shall be granted three years, from the date of publishing its executive regulations, to conform to the provisions of this law, without affecting compliance to the protection of law 48/1982, which deals with the provisions of the river Nile and waterways from pollution". [6]

Table (1) summarizes the provisions and some laws and regulations designed to address the pollution problems of potable water, wastewater, and seawater, which stipulate standards and regulations relevant to the Egyptian energy sector (aş given below). [7]

TABLE (1). EGYPTIAN LAWS AND REGULATIONS ON PROTECTION OF WATER RESOURCES

Law Number / Year	Subject of Law
Presidential Decree 27/03-1966	Establishes the Supreme Committee for Water, chaired by the Minister of Health, responsible for the approval of domestic and industrial wastewater disposal projects and any other possible sources of pollution to protect surface and underground waters.
Supreme Committee for Water(*), Annex IV 1-7-75, established by the Presidential Decree 27/03-1996	Establishes specifications, standards and maximum permissible limits of potable water. Indications of pollution: increase in ammonia, nitrates, COD, BOD chlorides, phosphates. It also defines the Bacterial Standards for chlorinated water and the requirements for sampling.
Minister of Housing and Utilities Decree 643-1962 implementing Law Number 93-1962	Refers to (1) specifications and standards that must be fulfilled for wastewater discharged to public sewers; and (2) specifications for disposal in the sea and on land, as well as the method and frequency of taking samples of wastewater.
Law 48-1982	Concerns protection of the Nile River and Egypt's waterways from pollution, it defines the surface waters and regulates discharge of wastes to bodies of water, see table (2).
Minister of Irrigation Decree Number 8-1983 implementing Law 48-1982	Section 6 sets regulations, standards and specifications for treated wastewaters before discharge to surface waters, see table (2).

Currently, Law No. 93 of 1962 and Law No. 48 of 1982, and their supplemental implementation decrees form the standing regulatory framework for wastewater discharges and water quality and management, and are applied by most of the energy subsectors.

(a) **Law 93 for 1962** addresses a variety of water and sewerage related issues and applies to all general kinds of water bodies. According to the law, emitters of wastewater must obtain licenses which "should indicate the standards and specifications of such wastewater". The law also gives standards for wastewater discharged into public sewers according to eight criteria (temperature, pH, settleable solids, granular solids, hydrogen sulphide, fats, poisonous substances, and sublimating gases susceptible to ignition).

(b) **Law 48 for 1982** "regarding the protection of the River Nile and Waterways from Pollution", and its Decree No. 8, defines targeted water bodies and discharge types much more specifically for a long list site types, discharges, and conditions. Water bodies falling under the jurisdiction of this law include fresh surface

1. The Case of the United States of America (USA)

Since the early 1970's, several Federal legislations that have had major impacts on the US electric power industry have been enacted. This part describes the National Energy Act of 1978, the Public Law 95-617-95-621 and the relevant Federal chemical effluent guidelines for new power plants. [5], [10]

(i) **National Energy Act** of 1978 – (Public Law 95-617 – 95-621), this Act was signed into law in November 1978 and includes five different statutes which were passed in response to the unstable energy climate of the late 1970's. (The oil ban of 1973). It includes the Public Utility Regulatory Policies Act (PURPA), the Energy Tax Act (Public Law 95-618), the National Energy Conservation Policy Act (Public Law 95-619), the Powerplant and Industrial Fuel Use Act (Public Law 95-620), and the Natural Gas Policy Act (Public Law 95-621). The provisions of the first three acts within the National Energy Act explained hereinafter. Both the Power plant and Industrial fuel acts and the Natural Gas Fuel Act are mainly regulating the type and quality of fuel to be used.

(b) **US Federal Chemical Effluent Guidelines for New Power Plants**, has been set by US-EPA for consideration by electric power utilities. Table (4) shows the set limits.

(c) **The Clean Water Act (CWA),** described earlier is also applicable to the electric power plants.

2. The case of the ESCWA member States

Limited water resources environmental standards have been developed for the electric power sector in the ESCWA region. However the sector is naturally subject to the prevailing ambient quality standards, as well as the wastewater quality. Examples of the limited available standards are given hereinafter for Egypt and Saudi Arabia:

(i) **In EGYPT,** in general the electric power sector applies several regulations for the use of water and the liquid effluent discharges as given by table (1) with those developed by law No 48 for the protection of water resources emphasis is given to Law No.4, 1994. [6] & [7]

Law 4 for 1994 applies certain planning conditions for developments along or adjacent to the coastline: (1) any measures which are likely to cause changes in the natural coastline (erosion, sedimentation, coastal currents and pollution from the project or associated works) are restricted, except with the approval of the concerned approving authority; and (2) any development within 200 m of the coast must gain approval from the authority.

In addition, Law 4 states that all establishments including power plants are prohibited from polluting the marine environment. Subsequently, no permit will be granted for an establishment on, or near, the coastline, which may result in discharges of polluting substances, and Annex 1 of the Executive Regulations of Law 4 sets out the Egyptian standards concerning the concentration of pollutants in effluent discharged to the marine environment.

(b) **In SAUDI ARABIA,** Meteorology and Environmental Administration (MEPA) promulgated its first Environmental Standards in 1401 H with the Revised Version published in 1409 H. These standards include the following water quality standards: [11]

(i) **Article (12):** on Receiving Water Guidelines;

(ii) **Article (13):** on Performance Standards for Direct Discharge calling for using the best available technology (BAT) for pollution control;

(iii) **Article (14):** on Pre-treatment Guidelines for Discharge to Central Treatment Facility.

C. RECOMMENDATIONS

In view of the above, it is recommended that:

(a) A concerted effort should be directed towards further assessment and analysis of USA and EU regulation and standards relevant to water resources with the objective of acquiring the most useful of it for implementation in the ESCWA MS at national and/or regional levels.

(b) There is a need for further coordination of efforts among water, energy and the environmental concerned bodies in the ESCWA region for developing a set of harmonized regulation and standards that can cover the spectrum of the energy sector impacts on water resources and appropriately secure its protection in the ESCWA MS as well as the region.

TABLE 2 (*Contd.*): WATER QUALITY STANDARDS AND SPECIFICATIONS MANDATED BY THE EGYPTIAN LAWS IN COMPARISON WITH THE WORLD BANK GUIDELINES (MG/LITER-UNLESS OTHERWISE INDICATED)

Parameter	Limits & Specifications for draining and disposing of certain substances in the marine environment mandated by Law 4/1994(a)	World Bank Wastewater Effluent Guidelines (1996)
Temperature	Not more than 10 degrees over existing level	3oC increase above ambient [b]
Ph	6-9	6-9
Color	Free of colored agents	
Biochemical Oxygen Demand (BOD)	60	-
Chemical Oxygen Demand (COD) (Dichromate)	100	
Total Dissolved Solids	2000	
Fixed (Ash of) Dissolved Solids	1800	
Suspended Solids	60	
Turbidity	NTU 50	50
Sulfides	1	
Oils and Grease	15	
Hydrocarbons, of oil origin	0.5	10
Phosphates	5	
Nitrates	40	
Phenolates	1	
Fluorides	1	
Aluminum	3	
Ammonia (Nitrogen)	3	
Mercury Compounds	0.005	
Lead	0.5	
Cadmium	0.05	
Arsenic	0.05	
Chromium, total	1	0.5
Copper	1.5	0.5
Nickel	0.1	0.5
Iron	1.5	1.0
Manganese	1	
Zinc	5	1.0
Silver	0.1	
Barium	2	
Cobalt	2	
Pesticides	0.2	
Cyanide	0.1	
Fecal Coliform Count (No. in 100ml)	5000	
Dissolved Oxygen		
Organic Nitrogen		
Total Alkalinity		
Sulphate		
Synthetic Detergents		
Phenol		
Selenium		
Chemical Oxygen Demand (Permanganate)		
Total Heavy Metals		-
Total Residual Chlorine		0.2 (c)
Total Coliform (MPN/ 100ml)		
Odour		
Tannin + lignin		
Carbon derivatives (chloroform)		

Table (4) Water Quality Standards in Saudi Arabia [11]

Pollutant	Receiving water guidelines (at the edge of mixing zone)	Effluent discharge standards Allowable Levels	Specific pretreatment guidelines for discharge to central treatment facilities Guidelines
Physico-chemical Pollutants			
Floatable	None attrib to discharge	None	
PH	0.1 pH Units***	6-9 pH units	5-10 PH units
TPS		8-15mg/I (max)	
Total Suspended Solids	5%*		2000 max
Temperature	1°C ***	Case by case	60 C
Oil & Grease	Mangnt Measures Reqd **		
Dissolved Oxygen	5%		
Turbidity	5%	Basis 75Ntu (max)	
Organic Pollutants			
Biological Oxygen Demand		25ppm	
Chemical Oxygen Demand	5%	150ppm	1500
Total Organic Carbon	5%	50ppm	1000
Total Kjeldahl Nitrogen	5%	5ppm	
Chlorinated Hydrocarbons	5%	0.1ppm	0.5
Oil & Grease	5%	8-15ppm	120
Phenols	5%	0.1ppm	150
Inorganic Pollutants	5%		
Ammonia	5%	1.0ppm	
Arsenic	5%	0.1ppm	1.0
Cadmium	5%	0.02ppm	0.5
Chloride	5%		
Residual Chlorine	5%	0.5ppm	
Chromium (total)	5%	0.01ppm	2.0
Copper	5%	0.2ppm	1.0
Cyanide (total)	5%	0.05ppm	1.0
Lead	5%	0.10ppm	1.0
Mercury	5%	0.001ppm	0.01
Nickel	5%	0.20ppm	2.0
Total Phosphate	5%	1.0ppm	
Zinc	5%	1.0ppm	10.0
Biological Pollutants			
Total Coliform	70 MPN/100ml (average for 30-day period)	1000MPN/100 ml	

Notes:

* All references to the percentage are maximum changes from typical local baseline conditions.

** Facilities using, transferring of storing oil and petroleum hydrocarbons are required to prepare, maintain and update a spill prevention, control and clean-up plan.

***Maximum change from typical local baseline conditions

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8. Jordanian Standards (JS) 202/1990.

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TABLE (3): JORDANIAN STANDARDS JS 202/1990
REQUIREMENTS FOR DISCHARGE OF INDUSTRIAL EFFLUENTS

Parameter	Maximum Allowable Limit (mg/L)+		
	Disposal to Wadis and Rivers	Groundwater Recharge	Reuse for Irrigation**
BOD5	50 M	50 M	-
COD	150 M	150 M	-
DO	1*	1*	1*
TDS	3000 (1)	1500 (1)	2000 (2)
TSS	50	-	10 (3)
PH (SU)	6.5 – 9.0	6.5 – 9.0	6.5 – 8.4
Color (Unit)	15	15	-
FOG	5	ABSENT	5
Phenol	0.002	0.002	0.002
MBAS	25	15	-
NO3-N	12 (4)	12 (4)	30
NG3	5	5	5
T-N	-	-	50
PO4-P	15	-	-
Cl-	500	500	350 (3)
SO4	500	500	400
F	1.5	1.5	-
HCO3	-	-	500
Na	-	400	-
Mg	-	-	-
Ca	-	-	-
SAR	-	-	9
Al	5	0.3	5
As	0.05	0.05	0.1
B	1	1	1 (5)
Cr	0.1	0.05	0.1
Cu	2	2	0.2
Fe	1	1	5
Mn	0.2	0.2	0.2
Ni	0.2	0.1	0.2
Pb	0.1	0.1	1
Se	0.02	0.05	0.02
Cd	0.01	0.02	0.01
Zn	15	15	2
CN	0.1	0.1	0.1
Hg	0.001	0.001	0.001
TCC MPN/100mL	-	-	-
TFCC MPN/100mL	1000 (6)	1000 (6)	1000 (6)
Nematodes	<1	-	<1

\+ All units are in mg/L except where noted
* Minimum value
** Depends upon type and quantity of crops, irrigation methods, soil type, climate and groundwater in the area concerned.
\- Undetermined
M Monthly average

Notes:

1. TDS allowable limit is subject to the TDS concentration in the water supply and the water basin affected.
2. Allowable limits of wastewater reuse determine the degree of reatriction (none, slight to moderate, or severe).
3. Method of irrigation is determined by wastewater quality being used.
4. Nitrate concentrations allowed are determined by its concentrations in the affected water basin.
5. Could reach 3 mg.L.
6. Geometric mean.

TABLE 2: WATER QUALITY STANDARDS AND SPECIFICATIONS MANDATED BY THE EGYPTIAN LAWS IN COMPARISON WITH THE WORLD BANK GUIDELINES (MG/LITER-UNLESS OTHERWISE INDICATED)

	Standards and Specifications Mandated by Law 48/1982					
	Quality of treated industrial liquid effluent allowed in fresh water bodies	Max limits of constituents in treated industrial liquid effluents discharged to (Art. 61)		Discharge into brackish and saline surface water bodies (Art.66)		Drain water standards (mixing with) fresh surface water bodies (Art 65)
Parameter		River Nile from its Southern Egyptian Border to the Delta Barrages	Nile Branches, main canals, branch canals, ditches and groundwater reservoirs	Industrial Liquid effluent	Sewage effluent	
Temperature	5°C above normal (Art-60)	35°C	35°C	35°C	35°C	5 C above normal average
pH	7-8.5	6-9	6-9	6-9	6-9	7-8.5
Color	Max 100degrees	No Col. Substance	No Col. substance			Max 100 units
Biochemical Oxygen Demand BOD	Max 6	30	20	60	60	Max 10
Chemical Oxygen Demand (COD) (Dichromate)	Max 10	40	30	100	80	Max 15
Total Dissolved Solids	500	1200	800	2000	2000	500
Fixed (Ash of) Dissolved Solids		1100	700			
Suspended Solids		30	30	60	50	
Turbidity						
Sulfides		1	1	1	1	
Oils and Grease	Max 0.1	5	5	10	10	Max1
Hydrocarbons, of oil origin						
Phosphates		1	1			Max 1.0
Nitrates	Max 45	30	30	40	5	Max 45
Phenolates				10	-	
Fluorides	Max 0.02	0.5	0.5	0.5	-	Max 0.5
Aluminum						
Ammonia (Nitrogen)	Max 0.5					Max 0.5
Mercury Compounds	Max 0.001	0.001	0.001			Max 0.001
Lead	Max 0.05	0.05	0.05			
Cadmium	Max 0.01	0.01	0.01			Max 0.01
Arsenic	Max 0.05	0.05	0.05			Max 0.01
Chromium, total	Max 0.05	0.05	0.05			Max 0.01
Copper	Max 1	1	1			Max 1.0
Nickel		0.1	0.1			
Iron	Max 1	1	1			Max 1.0
Manganese	Max 0.5	0.05	0.05			Max 1.5
Zinc	Max 1	1	1			Max 1.0
Silver		0.05	0.05			
Barium						
Cobalt						
Pesticides				nil	nil	
Cyanide	Max 0.1			0.1	-	Max 0.1
Fecal Coliform Count (No. in 100ml)						
Dissolved Oxygen	> 5			-	>4	>5
Organic Nitrogen	Max 1					
Total Alkalinity	20-150					50-200
Sulphate	Max 200					
Synthetic Detergents	Max 0.5	0.05	0.05			Max 0.5
Phenol	Max 0.02	0.002	0.001	0.005	-	Max 0.02
Selenium	Max 0.01					
Chemical Oxygen Demand (Permanganate)		15	10	50	40	Max 6
Total Heavy Metals		1	1	1.0	1.0	
Total Residual Chlorine		1	1			
Total Coliform (MPN/100ml)				5000	5000	Max 500
Odour						2 degrees
Tannin + lignin						Max 0.5
Carbon derivatives (chloroform)						Max 1.5g/l

These standards have already passed through minor revisions and modifications and its new versions were regularly published, the latest in 1409 H.

Water Quality Standards in Saudi Arabia are presently subject for major modifications and upgrade of these standards with special emphasis on the Water Body Classification and quality limits of such water bodies based on its "best uses" for various physic-chemical and biological parameters, trace metals and organic constituents for the water quality standards.

In future, Source Water Quality Standards need to be revised and upgraded with special reference to existing major critical industries in the country such as petroleum refineries, fertilizer industry, power and desalination plants, and chemicals factories.

III. CONCLUSION AND RECOMMENDATIONS

The paper presented a quick assessment of the environmental impacts of the energy sector in ESCWA MS on water resources which indicate the following:

A. The Energy Sector Environmental Impacts on Water Resources

The Oil and Gas Sector is heavily affecting water resources through the exploration, production, transportation as well as Oil and Gas industries; while the **Electric Power Sector** environmental impacts on water resources differ in accordance with plant type. For thermoelectric generation the impacts are mainly due to wastewater discharges and rarely due to spills of fuel used. While hydroelectric power plants affects the whole water stream and the site ecology.

The major environmental impacts of the energy sector on water resources are more linked to the marine pollution either through normal oil and gas operations or accidental oil spills or digesters. Meanwhile, surface waterways are mostly affected by the electric power sector, while the ground water resources can be affected by both subsectors.

B. The Environmental Regulations and Standards of the Energy Sector Relevant to Water Resources

In addition, the paper reviewed the relevant available standards and regulations available in USA, EU and ESCWA MS showing that:

In USA and EU, there are a stock of environmental standards that are directed towards the protection of different water resources and address several use options. Such regulation and standards have been subject to several amendments addressing issues that have been practiced through implementation and enforcement of such standards as well as provisions that are approaching harmonization of the standards on Federal level at USA or among member States at EU.

In the ESCWA Region, most of the ESCWA MS have developed regulations and standards for water resources protection including – in most of the cases – those relevant to the energy sector, particularly in the area of protection of marine water environment. However, the available standards are mainly primary standards that are either not covering the whole spectrum of the energy sector environmental impacts or not compatible with the prevailing requirements for water quality. In most cases, it fall short of securing the appropriate protection and sustainability of water resources. It can be noted that the two most developed and comprehensive regulations and standards addressing the interface between the water and energy sectors are in Egypt and Saudi Arabia.

waters, brackish surface waters, and groundwater reservoirs. Of particular interest are conditions under which permits and licenses must be obtained. The law is quite specific, defining standards for over 30 parameters for some water and effluent classification, including a variety of organic and inorganic chemicals.

(c) **Law No. 4 for 1994,** and its Executive Regulation (ER) included: [6]

(i) Articles 48 to 59, of the executive regulations of the law are devoted to the protection of marine water and seashores from oil pollution covering all relevant aspects. Its provisions include (1) it is forbidden for ships to discharge oil and oily mixtures into the national marine waters; (2) foreign oil tankers calling at Egyptian parts must comply with all the requirements of the regulation; and (3) companies authorized to explore, extract or exploit offshore oil fields, and oil transport facilities are forbidden to discharge any polluting materials resulting from their activities into the territorial sea or the exclusive economic zone of Egypt.

(ii) Articles 50-53 on pollution from ships; mandate all concerned parties responsible for oil transport consignments within ports, territorial waters, or the exclusive economic zone of Egypt, and the companies operating in oil extraction to notify the competent administrative bodies of every oil leakage incident upon its occurrence. They are obliged to take all actions set by these articles to protect air, water and soil of the country. Article 51 identified requirements for shipping parts, while articles 52, 53 stated all conditions for guarantee of ships certification and ships and waste disposal from ships.

Other provisions dealing with the protection of marine environment and coastlines are given later in this paper.

(b) **In JORDAN,** provisions governing environmental protection in Jordan can be found within numerous different pieces of legislation, and a new environmental law has recently been approved by the Parliament. Among the existing regulations there are some relevant to the water sector, however it does not emphasize any relevance to the energy sector. These include: [8]

(i) **The drinking water standards** issued by the Ministry of Industry and Trade in 1983;

(ii) **The Requirements for Discharge of Industrial Effluents, Jordanian Standards JS 202/1990** identifying the maximum allowable limits mg/l of different pollutant in industrial effluents when discharged to different water resources. Table (3) shows the limits set by such standards.

(c) **In OMAN,** the following Decree was issues in compliance with the law on the conservation of the environmental prevention of pollution issued by the Royal Decree No. 10/82: [9]

- **Ministerial Decree No. 145/93,** on wastewater re-use and discharge has prohibited the discharge of any drain water except that satisfying the requirement set in the law based on authorization from the Ministry of Environment. The wastewater quality for different re-use is stated by the Decree No. 7/84.

C. Environmental Regulations and Standards For the Electric Power Sector Relevant to Water Resources

The environmental regulations and standards for the electric power sector has a wide spectrum covering different water issues including: (1) Ambient water quality standards; (2) Performance standards, for liquid effluent discharges to the different water bodies; (3) Technological standards, for wastewater treatment and control technologies; and (4) Practice standards, prohibiting the discharge of wastewater to certain environment. The following is a brief assessment on such regulations and standards particularly those enacted by US-EPA, and the ESCWA member States.

into navigable waters unless a permit is obtained under the Act, and it authorizes EPA for the delegation of many permitting, administrative, and enforcement aspects of the law to state governments, while EPA still retains oversight responsibilities.

(c) **The Safe Drinking Water Act** (SDWA), regulates, at the Federal level, the processes for injection of the produced water deep underground for enhancing oil recovery with the objective to protect groundwater, and to manage any site-specific risks.

2. The Case of the European Union (EU)

Water is one of the most comprehensively regulated area of EU environmental regulations and standards. However, those applied to the Oil and Gas sector in Europe are addressed within a set of directives that are mainly concerned with the conservation of natural resources, particularly air, water and land resources. The EU has issued several directives for the protection of water resources including the following: [(2)]

(a) **The Water Quality Directives**, a framework directive which will be replaced by a much broader IPPC Directive in 2007. It include the Drinking Water Directive (1975) and the Surface Water Directive (1980), including different water quality standards and emission limit value legislation.

(b) **The Groundwater Directive 80/68/EEC, on the protection of groundwater**, seeks to control the direct and indirect discharge of certain substances into the groundwater, where any discharge to groundwater is prohibited and must be subject to an elaborate authorization procedure. Member States are requested to monitor compliance with the authorization and the effects of discharges.

In the 1990's a wave for revision of water legislation had emerged in the EU and was directed towards the identification of necessary improvements and gaps to be filled in the existing legislations. This has included the development of a Groundwater Action Programme and a 1994 proposal for an Ecological Quality of Water Directive. In 1995, the European institutions agreed that a fundamental review and restructuring process was needed for Community water policy. Also during this time it had become, after extended discussion at member States and community level, increasingly clear that an efficient protection of water needed emission limit value legislation as well as water quality standards legislation, i.e., a so-called combined approach.

(c) **The IPPC Directive** was adopted in 1996 for large industrial installations (such as Oil and Gas industries) covering water pollution.

(d) **The Water Framework Directive (1997).** The Commission adopted, in February 1997, its proposal for a Water Framework Directive. Its purpose is to establish a framework in order to achieve sufficient provision of drinking water and other economic requirements and protection of the environment. The general environmental objective of the Directive is to achieve "good status" for all ground waters and surface waters by 2010 at the latest.

3. The Case of ESCWA member States

The Oil and Gas sector in the ESCWA MS has developed several environmental standards and regulations to protect the national natural resources "air, water and soil" against the adverse impacts of the different oil and gas operations. Examples from the regulations and standards issued by ESCWA MS for the abatement of the Oil and Gas adverse environmental impacts on water resources in Egypt, Jordan, and Oman are given below:

backwater effect, flooding and water logging upstream, salinization of floodplain lands, salt water intrusion in upstream, and increasing water loss through transpiration.

II. THE ENVIRONMENTAL REGULATIONS AND STANDARDS FOR THE ENERGY SECTOR RELEVANT TO WATER RESOURCES

Environmental standards and regulations have been used worldwide, among a wide variety of policy instruments for environmental management. They are generally established through the executive regulations following the enforcement of an environmental law or within the framework of regulations that are issued by other concerned authorities such as in the case of water management and health standards.

Standards and regulations can be set either by the government or by industry itself. Standards can also take the form of guidelines or voluntary limitations, which is non-enforceable government suggestions concerning products or business behavior. Meanwhile, the environmental quality standards should be carefully tailored to suit national priorities, local ecology, economic, social and environmental conditions.

A. CLASSIFICATION OF ENVIRONMENTAL STANDARDS

The water sector regulations and standards that are relevant to the different energy subsectors can be classified as follows: [4]

1. Environmental Ambient Standards

Environmental ambient standards are goals for the quality of the ambient environment that set maximum allowable levels of pollutants in the receiving medium either air, water or soil. It can be either primary standards to protect health only or secondary standards to protect against effects on other systems.

Most of the ESCWA (MS) have established ambient standards, where the priority in most of the cases was given to the development of primary air and water ambient standards with the aim of protecting the public health and reducing the health hazards. Secondary ambient quality standards are nearly not existent in the ESCWA region.

2. Environmental Performance Standards

Environmental performance standards aim at prescribing to industry an objective benchmark against which to measure acceptable performance, or to provide common reference points for quality control. It puts limits to the amount or rate of particular chemicals or discharges that a facility can release into the environment in a given period of time "emissions standards". Regarding water resources these standards are mainly used to specify wastewater discharges to water streams as well as the treated water requirements. These standards are widely used in the region for regulations, permits, and monitoring requirements. However, in many cases, inadequate and do not cover the wide spectrum of complex and modern pollutants emitted to the natural environment of the region.

3. Environmental Practice Standards

Environmental practice standards require or prohibit certain work activities that have significant environmental impacts. They are widely recognized and implemented in ESCWA MS, particularly in the protection of occupational environment and in the management and control of hazardous chemicals. An example is the prohibited uses to protect coastal marine areas.

1. Impacts of the Oil and Gas exploration and production

The major development phases of the oil and gas exploration and production include, geophysical surveys, drilling wells, construction of transportation and processing infrastructure, production platforms, re-injection wells, storage tanks, separators, and ancillary support facilities.

In 1996, the ESCWA member States (MS) oil and gas activities reached 308 seismic exploration crew/month, a total of 183 active rigs and more than 2500 km of exploratory drilling were achieved together with 1092 productive wells. This can indicate the huge environmental impacts on water resources of exploration and production in the region including:

(a) **Water pollution.** Contamination of local surface waters, leakage from pipelines, pits and storage tanks, rain water runoff from roads, pads and other paved or packed surfaces, improper handling of domestic sewage and wastes from equipment maintenance and erosion of disturbed soils. In addition, local water sources may diminish by the extensive use rate of Oil and Gas community;

(b) **Accidental oil spillage.** Offshore Oil and Gas development carries with it the risk of oil spills at the platform and in transporting the oil from the platform to shore. The environmental impact of an offshore spill depends on, the type of oil; the size of the spill; and weather conditions. The percentage of oil recovered from a spill is usually between 10-15%. Generally the spills and leaks may cause considerable environmental damage, particularly if it is a highly toxic oil or a heavy crude. The marine environment in the ESCWA region is subjected to considerable stress through the deliberate or accidental oil spills;

(c) **Produced water**. Oil reservoirs may contain considerable quantities of water, (fossil or formation). During production, formation water may come to the surface and will be separated from the oil and/or gas. This water, which contains hydrocarbons and chemicals from the reservoir and chemicals injected during production is called 'production water' and is generally discharged into the sea after simple treatment. The American Petroleum Institute (API) estimated that six to eight barrels of water are produced for each barrel of oil. Produced waters are principally salt solutions with higher metals concentrations than in seawater. Produced water may also contain radionuclides, and contains high concentrations of oil which is allowed to separate in a gravity separator, and then be treated to remove dispersed oil before being discharged into the sea.

2. Impacts of the Oil and Gas transportation and industries

Several Oil and Gas industries were developed in the ESCWA region, particularly refineries, petrochemicals and liquefying Natural Gas (NG). In 1996, the installed refinery capacity reached 4.88 mbl/day. Oil and Gas transport is usually by pipeline, occasionally by barge or tanker to shore-based refineries and/or gas processing facilities. The intra-industry trade among countries in the region is associated with increased national and intra-regional network of pipelines for oil and gas. The ESCWA MS also have 77 oil tanker fleets with 6.52 million tons capacity and 9 liquid gas carriers with a total of 602.000 m^3 capacity. In addition, more than half of the world's petroleum has been estimated to pass through the waters of the Arabian Gulf to its adjacent Gulf of Aden. The environmental impacts of oil and gas industries and transportation include mainly:

(a) **The environmental impacts of Oil and Gas industries** are mainly related to petroleum refineries where large quantities of water are used in petroleum refining. The major pollutants present in its wastewater discharges are oil and grease, ammonia, phenolic compounds, sulfides, organic acids, and chromium and other metals. These pollutants may be expressed in terms of biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total organic carbon (TOC). In addition, there is a potential for serious surface water, soil, and groundwater contamination and degradation from leaks or spills of raw materials or products;