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HARMONIZATION OF ENVIRONMENTAL STANDARDS IN THE WATER SECTOR IN EGYPT

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1. INTRODUCTION

Worldwide water is becoming increasingly scarce. In times past, at least in non-desert areas, water availability was unquestioned. Water was easily available from surface or groundwater sources and ready to be applied in multiple uses (Attia, 1997a). With increasing population growth on one hand, and environmental degradation on the other, there is an increasing pressure on water and water systems for direct consumption and for productive use.

Egypt is an arid country with rapid population growth and crescent living standards. The natural and geographical conditions of Egypt are not auspicious in terms of fresh water resources availability. The generative watershed of the Nile, which is the main source of water for the country, is totally located outside Egypt's international borders. Downstream of Atbara River in Sudan, the Nile has no other tributaries and it continues as a single channel until it penetrates the Sudanese – Egyptian borders. The Nile morphology and the barren desert that bounds the Nile Valley and Delta constitute a geographical barrier that prevents the Egyptian from fully utilizing their territories. On the other hand, most of the available groundwater in the desert is non-renewable and with a high development cost.

Agriculture has always been the core of the economic development and is considered as the main activity for a large sector of the population. It contributes to one fifth of the gross domestic income and consumes over 85% of the total water supply. Municipal and industrial uses account for 15% of the total water consumption in the country, while river navigation and hydropower generation are considered as non-consumptive uses.

Although the international community has acknowledged Egypt's efforts in birth control, the population still gained great momentum and will continue to grow. The population growth and escalating living standards have put more stress on both land and water resources. Increased industrial growth together with intensified agriculture also has a direct impact on surface as well as groundwater quality. Environmental degradation will further develop unless proper management measures to improve and assure standards of water quality are implemented

The Ministry of Public Works and Water Resources (MPWWR) is the main public authority in charge of managing, developing and protecting water resources in Egypt. MPWWR is also responsible for formulating the national water policy for the 21st century to face the challenge of water scarcity. Availability of water is also constrained by its degraded quality, which limits its use for specific purposes. The policy's overall objective is to utilize the available conventional and non-conventional water resources to meet the socio-economic and environmental needs

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3. SURFACE AND GROUNDWATER RESOURCES

Rainfall in Egypt is very scarce except in a narrow band along the northern coastal areas, where an insignificant rain-fed agriculture is practiced. Rainfall occurs in winter in the form of scattered showers. The total amount of rainfall may reach 1.5 billion cubic meters (bcm) per year. This amount cannot be considered a reliable source of water due to its spatial and temporal variability. Sparse flash floods also occur in the Sinai Peninsula and in Upper Egypt.

Egypt receives about 98% of its fresh water resources form outside its international borders. This is considered to be a main challenge for water policy and decision-makers in the country as the river provides the country with more than 95% of its various water requirements. The Nile River is the second longest river in the world, being about 6,800 km. Its basin covers an area of about 3,000,000 square kilometers. The river travels through ten African countries; Tanzania, Kenya, Burundi, Rwanda, Democratic Republic of Congo, Eritrea, Ethiopia, Sudan and Egypt (Figure 1). Figure 1 shows the Nile River and the two main tributaries providing it with its water supply; the Blue Nile originating form the Ethiopian Plateau, and the White Nile originating from the Equatorial Plateau.

The average annual yield of the river is estimated at 84 bcm at Aswan. The discharge of the Nile River is subject to wide seasonal variation. The natural river flow can be divided into two periods: 1) A short 3 month long high muddy flow season, and 2) A longer 9 month long flow clear season. Figure 2 displays the annual river natural flow for the period 1871 – 1996. According to the 1959 Agreement with Sudan, Egypt's annual share of the river water is determined by 55.5 bcm. The agreement also allocates 18.5 bcm for Sudan, while about 10 bcm are considered as various water losses at the Aswan High Dam (HAD) reservoir site.

HAD was constructed at about 6 km south of Aswan. It is considered to be the major regulatory facility on the River. It has been operating since 1968 ensuring Egypt's control over its share of water and guiding its full utilization. Figure 3 shows the regulated reservoir releases and the reservoir storage during the period 1968/69 – 1997/98. Downstream HAD, the Nile water is diverted from the main stream into an intensive network of canals through means of control structures. The main function of these canals is to provide water for agricultural use. The agriculture drainage water is then collected through a network of tile and open drains. In Upper Egypt, most of the collected drainage water flows back to the Nile as return flow, while in the Delta, drainage water is pumped into the Mediterranean and the northern lake.

Groundwater is also an important source of fresh water in Egypt both within the Nile system and in the deserts. Groundwater in the Nile aquifer cannot be considered an additional source of water as it get its water from percolation losses from irrigated lands and seepage losses from the irrigation canals. The storage capacity of the Nile aquifer system is about 500 million cubic meters (mcm). Therefore, its yield must not be added to the country's water resources. Therefore, this aquifer should only be considered as a reservoir in the Nile River system with about 7.5 bcm per year rechargeable live storage. Groundwater also exists in the Nubian sandstone aquifer in the Western Desert region and Sinai. This aquifer is mostly deep and non-renewable. The total groundwater storage volume has been estimated at 200,000 bcm (Attia, 1997b). Current total abstraction from this aquifer is estimated at only 0.5 bcm per year. There are other smaller aquifers in Egypt such as:

irrigation purposes. The Bahr El-Baqar drain can be considered as a hazardous example of water quality degradation in Egypt.

Nevertheless, primary treatment of urban sewage is in general insufficient to prevent a further deterioration of vital water bodies. Even secondary treatment is not sufficient to ensure the possibilities of water reuse and prevent a further pollution with nutrients and pathogenic bacteria. From a public health point of view, special attention should be given to improve the sanitary conditions of the water system. This might require the tertiary treatment and the introduction of disinfecting methods.

Bacteria and pathogens found in domestic wastewater are responsible for the spread water-borne diseases such as typhoid, infectious hepatitis, cholera, and infant and child diarrhea in Egypt. Contamination of surface water is still prevalent in rural areas. This is manifested in the prevalence of schistosomiasis (bilharzia) among farmers. Despite the significant improvement in health services, still infant and child mortality remains at high level. Water contaminated with heavy and trace metals could have an adverse effect on human, animals, fish and crop production.

5.2.1.2. Industrial Waste Water

Egypt has about 20,000 industrial facilities, only 700 of which are major ones. The General Organization for Industrialization (GOFI) of the Ministry of Industry reported in 1992 that the majority of the industrial facilities are publicly owned, with 330 managed by the Ministry of industry and 120 by other ministries. Many publicly owned facilities receive water from the River Nile or large canals and discharge liquid waste back into the river, drains or the northern lakes.

The main industries in Egypt are food processing, textile manufacturing, pulp and paper, cement production, fertilizer production, pharmaceutical products, oil and petrochemicals, and heavy industries such as steel, machinary and chemicals. Most of theses industries are concentrated along the Nile River and its main branches around Cairo and Alexandria. The industrial wastes generated from these industries are considered as one of the main sources of water pollution especially. Industrial pollution can be categorized as point source of a wide variety of pollutants, of which heavy metals and toxic compounds generate the most concern. These pollutants originate primary from heavy engineering, electroplating and chemical industries. It becomes clear that industrial pollution is most severe in the drainage canals and sewerage systems followed by the irrigation canals and the Nile river. As the drainage canals in the Nile Delta discharge to the Northern Lakes and the Mediterranean Sea, the coastal area inevitably gets its grim share of water pollution.

Local contamination problems are significant in the Greater Cairo area with a population of approximately 15 millions and many industrial and commercial activities. Heavy industry, tanneries, chemical, textile and spinning, steel and galvanizing, food processing, petrol and car service stations, bakeries, marble and tile factories provide an over view of the typical effluent contaminants that can be expected.

Heavy metals in the water resources, irrigated soils or crops pose a number of risks. These include animal and human public health risks, accumulation of excessive concentrations in crops, which can limit or prohibit their use as foodstuffs. Cadmium, copper, chromium, lead, mercury, nickel, and zinc can all accumulate in crops to concentrations, which would limit the use of crops. Selenium also agriculture with a similar growth but not at the same rate as fertilizers. Yet, the use of pesticides in agriculture has been declining due to environmental legislation.

5.2.1.4. Navigation pollution

The reverie fleet comprises of over 9,000 units contributes to the river pollution by oil and grease, as well as domestic waste inputs. Oil and grease are often toxic to aquatic life and may inhibit the transfer of oxygen when floating on the surface. In addition to operational spilling, more serious pollution inputs can occur in case of accidents.

5.2.2. Major Types of Pollutants

In conclusion, the major types of pollutants associated with various activities described in the above sections can be summarized as:

- Salinity, mainly from agriculture (TDS, Cl)
- Oxygen demand substances, mainly from domestic and industrial sources (BOD, COD)
- Nutrients, mainly from agricultural, domestic, and industrial activities (NO3, NH4, PO4, org-N)
- Heavy metals, mainly from industrial activities (Cd, Hg, Pb)
- Pesticides, mainly from agricultural and some industrial activities (DDT, y-HCH)
- Hydrocarbons, mainly from industrial and navigational sources (oil and grease)
- Organic micro-pollutants, mainly from industrial activities (PCB's, PAH's)
- Bacterial pollution, mainly from domestic and industrial sources

In general, water quality problems fall into two broad categories: microbiology contamination responsible for acute diseases and chemical contamination, which poses cumulative and chronic health risks to human beings and aquatic life.

5.3. Impact of Climatic Changes on Water Resources

Analysis of historical and recent fluctuations in water resources reflects a variety of both natural and anthropogenic causes. Natural factors include changes in precipitation, evaporation, and vegetation, while anthropogenic factors include human induced land cover and creation of artificial water bodies.

Climatic changes may also have an impact on water demands as well. It is expected that changes in temperature would result in an increase in crop water consumption. This would significantly increase the country's water demands as agriculture represents the main water user.

However, no reliable climatic models are available on regional and there is no established methodology for assessment of climatic changes on water resources. Thus impact of climatic changes on water resources in Egypt is not yet well identified.

6. INCORPORATING ENVIRONMENTAL ASPECTS IN WATER RESOURCES MANAGEMENT

MPWWR is developing its integrated water resources planning and management policy for the 21st century considering water quality issues, environmental

Table 2. Article 61: The standards set by the Ministry of Health for permits to discharge treated industrial liquid effluents into the fresh water bodies and groundwater reservoirs are: (All standards are in mg/liter unless otherwise noted)

Parameter	***The maximum limits of constituents in treated industrial liquid effluents discharged to :***	
	River Nile from its Southern Egyptian Border to the Delta Barrages	***Nile Branches, Main Canals, Ditches & Groundwater Reservoirs***
Temperature	35° C	35° C
HP	6-9	6-9
Color	No col. substance	No col. substance
Biochemical Oxygen Demand	30	20
Chemical Oxygen Demand (Dichromate)	40	30
Chemical Oxygen Demand (Permanganate)	15	10
Total Dissolved Solids	1200	800
Fixed (Ash of)Diss. Solids	1100	700
Suspended Solids	30	30
Fixed (Ash of) Susp. Solids	20	20
Sulphides	1	1
Oil & grease & resins	5	5
Phosphate (inorganic)	1	1
Nitrate-N	30	30
Phenol	0.002	0.001
Fluorides	0.5	0.5
Residual Chlorine	1	1
Total heavy metals	1	1
this covers:		
*Mercury	0.001	0.001
*Lead	0.05	0.05
*Cadmium	0.01	0.01
*Arsenic	0.05	0.05
*Chromium (hexavalent)	0.05	0.05
*Copper	1	1
*Nickel	0.1	0.1
*Iron	1	1
Manganese	0.05	0.05
Zinc	1	1
Silver	0.05	0.05
Synthetic Detergents	0.05	0.05
Total Coliform (MPN/100ml)	2500	2500

can not be taken under law 48. More recent pollution control measures are the concentration of industries in areas in the desert and the reduction of direct industrial effluents to the river Nile through a combination of prevention and treatment measures.

In the domestic sector the responsibility for pollution control lies with several institutions. Individual households, local councils, sanitary drainage authorities and governorates, all have a role in pollution control. Law 48 applies the same license obligation to domestic source as it does to industrial sources with the added constraint that no discharge is allowed to the Nile, irrigation canals or the groundwater. The only applied method is treatment.

6.3. Current Water Quality and Environmental Monitoring Activities

During the last decade, considerable attention has been given to the monitoring of water quality and the establishment of monitoring programs. Various institutions belonging to several ministries have conducted monitoring activities on water quality, each according to their own mandate, requirements, and properties. A few of these institutions are situated within the National Water Research Center of the MPWWR while others operate under other different ministries. An overview of the more significant monitoring activities is presented in the following section.

Previous reviews of the monitoring programs in Egypt indicate that even with the number of on going monitoring activities the knowledge of the status of water quality is rather limited and does not present an over all coherent picture. There are gaps in information in particular regions and most of the monitoring effort has been directed at the basic physical. Moreover, chemical parameters. Very little monitoring has been done that will enable an understanding on the source, transport and fate of water pollution constituents and the effects of these constituents.

Various institutions within different ministries are involved in the monitoring of water quality and the analysis of its data. The more significant agencies are:

6.3.1. National Research Center (NRC)

Until 1982, a large program for monitoring the Nile River water quality was conducted with the support of Michigan University. The Center presently receives so substantial financial assistance from external sources. A number of relatively small monitoring projects related to water treatment in Cairo are carried out with support from the Academy of Sciences and Technology. NRC does not execute regular monitoring programs, but ad-hoc program for specific studies and researches.

6.3.2. Ministry of Health (MOH)

Ministry of Health is responsible for public health. Since the Nile provides drinking water for most Egyptians, its water pollution is considered to be a main concern for MOH. The Environmental Health Department is responsible for sampling drinking water of treatment plants, sanitary sewage, and industrial discharges according to specifications and standards of Law 48/1982. It is also responsible for establishing water standards for various uses.

MOH operates two well-equipped laboratories in Greater Cairo and less sophisticated ones in various governorates. Monthly physical, chemical, and bacteriological analysis is carried out for water samples in 300 locations.

locations and the remaining 22 sites were considered as a minor site or micro-locations. The purpose of the micro-locations was to fill the gaps between the major sites and to present different stages along the river. In addition to the 35 sites, all of the sites of discharge of the pollution sources along the Nile River were sampled.

Since 1991 NRI has carried out a water quality monitoring program for Lake Nasser in both its Egyptian and Sudanese parts. The objective of the program was to assess the effect and understand the relation between water storage and water quality. The program was implemented with the co-operation with the High Aswan Dam Authority. Eight campaigns were conducted on the lake as once a year sampling campaign. Weekly samples were collected at Abu Simple from June 1994 until December 1994 and monthly samples from December 1994 to June 1995.

6.3.4.2. Drainage Research Institute (DRI)

Monitoring of the drainage water quantity and quality is the mandate of Drainage Research Institute, which has already made important steps to such monitoring and analysis programs. Since the 1980's the DRI has been monitoring the drainage water and its reuse, focusing on the water quantity, salinity and water quality in the main open drainage system in the Delta. Yearbooks have been published to present the data collected on the quantity and quality of drainage water.

DRI, representing the Government of Egypt, jointly with Delft Hydraulics of the Netherlands executed the Monitoring and Analysis of Drainage Water Quality (MADWQ) project. The monitoring and analysis of the water quality in the drainage system in the Nile Delta and the Fayoum Directorate was the main concern of the MADWQ project. The project aimed at strengthening the capabilities of the DRI staff in the field of water quality monitoring and analysis, and widening the scope of research through the institutional support. The monitoring program in its future settings will provide tools and in establishing an environmentally sound policy for the reuse of the drainage water. The project set up and implemented an integrated measuring network to monitor drainage water quality in the Nile Delta and Fayoum Governorate with regular publication of data and data-interpretations. The project also demonstrated the use of mathematical models to support drainage water management to maximize the benefit of reuse of acceptable quality drainage water.

6.3.4.3. Research Institute for Ground Water (RIGW)

This institute is in charge of the, monitoring, and evaluation of groundwater in the Nile and desert aquifers. With the assistance of the Netherlands the installation of a monitoring and information system for groundwater quality at about 150 reference locations have been conducted.

6.3.4.4. Environment and Climate Research Institute (ECRI)

Environment and Climate Research Institute (ECRI) was established in 1994 to study the long term impacts of climatic changes on water resources and develop the appropriate measure to cope with such changes. It was also responsible for initiating the development of an integrated national water quality monitoring network. The institute is also in charge of collecting water quality data and information, analyzing the data and disseminating the important information on water quality to the interested parties.

6.3.4.5. Central Laboratory for Environmental Quality Monitoring (CLEQM) water quality for reuse in irrigation. However, adjustments may be required for some of these locations and additional monitoring sites are needed to be distributed over the not covered stretches. It is also decided that extra locations are required to represent the entire irrigation canal commands and drainage catchments. Monitoring sites at hydraulic and irrigation structures (syphons and bridges) will be covered as well. It is important to monitor at the expected polluted spots to gain insight in the extent of the pollution and to be able to trace the sources of pollution (black spots). Special attention is also given to the system outflow as it affects the Nile, Mediterranean, inland and northern lakes.

Monitoring frequency is selected to provide the necessary information about the seasonal variation in water quality at all monitored locations of the networks. It is also constrained by the availability of financial and human resources. The set of parameters to be analyzed is carefully selected according to the characteristics of each water body considered in the monitoring program. The design of the monitoring network should allow dynamic process changes as more information becomes available, new projects are in operation or changes occur in the water use scheme.

6.4. Environmental Public Awareness

One factor impeding sustainable water resources management is the lack of awareness of the state of water resources in terms of availability and demand, as well as, the economic, social, environmental and management aspects relating to water use (Abdel-Gawad, 1997). Increased public awareness is a key factor in building a constituency for environmental protection. It can be considered as important as scientific knowledge. Public awareness should be built at the individual and national level, among all water users and stakeholders. It is important to initiate a continuous mechanism for improving water and environment knowledge at the public level.

Intensive information given to the public through education, media and printed materials on the importance of water and sustainable development in general are a prerequisite for public awareness. To achieve real public participation in environmental management, public are required to modify and change their practices in order to conserve their limited water supply and protect it from pollution. Water should no longer be thought of a free good. Public should understand that it is a finite resources with many supply constraints. General public, primarily farmers, should understand that water contamination leads to water-borne diseases, impacting human health and productivity. They should also be informed about the consequences of environmental problems on the quantity and quality of water resources.

In order to meet this pressing need, which is not widely known, efforts are being initiated by the Government of Egypt (GOE) to change public behaviors and practices through outreach and communications program. The MPWWR has recently established a unit called "Water Communication Unit" which focuses its activities on producing printed materials, educational fact sheets, and information packages for water users, schools, etc.

On the other hand, the Egyptian media is paying more and more attention to environmental issues. A weekly Environment Page is published in a widespread

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morning newspaper. Weekly programs on environment are broadcasted on the Egyptian Radio and Television networks.

7. CONCLUSION

The scale and urgency of the environmental challenges presented by water stress in Egypt is clear. This calls for a shift in approach from facilitating infrastructure supply to demand side management which focuses on the more efficient use of water by water saving and conservation, reduction of losses, less low quality generated from different water uses, and more efficient water recycling and reuse.

Environment and water pollution problems have been clearly identified to help in the formulation of water resources planning and management strategy. Some of these problems seem to be broadened due to the present inappropriate water management practices such as drainage water reuse policy. This does not necessarily denote stop or prohibit such policies, rather take the proper measures and actions to control their degrading effects. Usually, conservation of natural resources is very expensive and pays off on the long run. Similarly, the cost of environmental deterioration cannot, sometimes, be compensated or accepted. Human health deterioration, cultural heritage damage, and natural resources depletion are good examples of a cost that is not acceptable to be paid by any society. The issue of global warming is one of the challenges that currently face water policy makers. Its contemporary impacts are fairly traceable while in the next century they will be more substantial. Nevertheless, reliability of the existing tools to predict these impacts is still questionable and scientists are putting a lot of time and effort in predicting future impacts.

Several actions have been suggested and currently being implemented by Government of Egypt to face and resolve the expected environmental problems in the future. The Egyptian Environmental Affairs Agency (EEAA) is established to be the main authority responsible for evaluating and protecting the environment represented by air, water and soil. EEAA does not perform regular monitoring activities rather helps in financing monitoring activities carried out by other governmental agencies. Key actions are legislation and pollution prevention, environmental education and stakeholders participation. Several laws have been issued for the environmental protection; especially for the prevention of water pollution. What is needed now is more timely and coordinated intervention by all parties, from an enlightened and informed public and NGOs, to government and decision makers at various levels and the relevant international agencies. There are several necessary tools and guidelines required to properly manage the reuse of low quality water. Monitoring is an essential step in water recycling and reuse. Current water monitoring activities are expected to fill the information gap on water quality to assist decision-makers in formulating sustainable water resources policies for the 21st century.

The cooperation at both the national/regional and international levels should be regarded as essential to solve the existing and future water problems. Exchange of know-how technologies and experiences of developed countries will help alleviate the problems.

The Central Laboratory for Environmental Quality Monitoring (CLEQM) was established through the consideration of merging the existing laboratory facilities at the research institutes of NWRC into a newly constructed accredited modern laboratory with proper infrastructure, equipment and trained staff. The main purpose of CLEQM is to provide a comprehensive and accurate assessment of the environmental quality of surface water, groundwater, soils, sediments and plant tissues associated with the Nile River and its water distribution canals, groundwater aquifers, as well as agricultural drains. CLEQM has identified the parameters to be analyzed in four categories:

1) General water quality parameters (pH, conductivity, carbonates, major ions, TDS, TSS, etc.);
2) Conventional pollution indicators (DO, BOD, COD, oil and grease, Ammonia, Nitrate, Nitrite, etc.);
3) Non-conventional pollution indicators (heavy metals, phenols, pesticides, bacteria, pathogens, etc.);
4) Soil parameters (size distribution of soil aggregate, soil moisture, hydraulic conductivity, etc.).

6.3.4.6. National Water Quality and Availability Management (NAWQAM), NWRC

The National Water Quality and Availability Management (NAWQAM) project is jointly undertaken by MPWWR, Egypt and the Canadian International Development Agency (CIDA) The project aims at developing an improved and integrated sustainable water resources management policies. The project has three operational components of which the National Water Quality Monitoring is implemented by DRI, NWRC.

The Water Quality Monitoring Component of the project aims at rationalizing water quality monitoring activities into a national program. The expected output of the monitoring activities is a clear understanding of both the spatial and temporal variation in water quality of the water resources systems in Egypt. It is expected that the project would provide the Egyptian water policy and decision-makers with the necessary information concerning the water quality to achieve improved and more efficient management of the national water resources. Three specific outcomes are identified for this component. The first outcome is improved timeliness and reliability of relevant and accurate water data as generated by NWRC. The second outcome is improved water data storage, retrieval and analysis by NWRC. Finally, improved implementation and dissemination of water information to and from stakeholders in forms suitable for influencing policy dialogue and formulation.

The water bodies under consideration for this project are determined as the Nile River and its two branches, the irrigation canals, the drainage canals, Lake Nasser, and groundwater wells. Considerable effort has been made in the design of the water quality monitoring network. There are various criteria used for the selection of the monitoring locations, determination of the frequency of sampling, and choice of the parameter set to be analyzed.

For the selection of the monitoring sites, it was decided to sustain the existing monitoring networks operating by NRI and DRI along the Nile River and the drainage network, respectively. The current monitoring programs have been operating for 15 years and locations are well established. Current locations are located upstream and downstream the reuse pump stations to ensure the suitability of

Two national monitoring programs (air, soil and water) are carried out by the Environmental and Occupational Health Center (EOHC) and financed through the Egyptian Environmental Affairs Agency (EEAA). There is also an inter-ministerial committee on Nile River water safety chaired by MOH.

6.3.3. Ministry of Agriculture and Land Reclamation (MALR)

The Soil, Water and Environment Research Institute (SWERI), within the Agricultural Research Center (ARC), carries out water sampling and analysis programs for special field research, mainly directed to salinity. Specific monitoring is executed for research purposes in relation to the effect of water pollution on the quality of agricultural output.

As of 1995, ARC operates a modern pesticides laboratory (Agriculture Central Pesticides Laboratory) that is equipped with the capability to analyze the heavy metals. Furthermore, SWERI claims to monitor 4000 groundwater wells on nitrates and heavy metals.

6.3.4. National Water Research Center (NWRC) of MPWWR

6.3.4.1. Nile Research Institute (NRI)

Since 1976 a water quality-monitoring program for the Nile River has been conducted for a number of chemical, physical, and biological parameters. The program was implemented with the co-operation of the ministry of Health from 1976 to 1986. The main objective was to evaluate the quality of the water in the Nile River and to determine the effects of pollutants on water quality for different uses.

The original sampling was carried out at the 10 km intervals along the Nile (totally 390 monitoring points) with a relatively high frequency. It was replaced in 1989 by a network of only 35 monitoring sites. In addition, more than 100 monitoring points are situated upstream and downstream the outlets discharging effluents to the Nile River. The sampling locations of the program fell in 2 categories; 270 sampling sites along the Nile River from the High Aswan Dam to the Delta barrages (about 950 km) and 128 sampling points at waste discharges points. They included 72 locations of agricultural drainage discharge and 56 locations were for industrial effluents.

Most samples were analyzed for pH, temperature, conductivity, dissolved oxygen, ammonia, nitrite, nitrate, biochemical oxygen demand, chemical oxygen demand, total dissolved solid, suspended solids, total hardness, alkalinity, major anions and cations, oil and grease, phosphate, and fecal coliform. The analysis were carried out by different laboratories including the central laboratory and the regional ones of the Ministry of Health, Environmental and Occupational Health Center, and the Soil and Water Dept. Faculty of Agriculture at the University of Alexandria.

In 1991, the Nile Research Institute started a modified monitoring program supported by the River Nile Protection and Development (RNPD) project supported by the Canadian Agency for International Development (CIDA). The main objectives of this program were: 1) to serve as a general reference for water quality conditions of the River Nile, 2) to detect waste discharge violations and maintain effluent standard, and 3) to determine the quantitative seasonal variation in water quality for the Nile River and for the point sources of pollution.

The sampling locations under the RNPD program were 35 sites along the Nile River and its two branches. Thirteen of these sites were considered as major or macro-

Table 3. Article 66: Sewage and industrial liquid effluents which are licensed to discharge into brackish or saline surface water bodies must comply with the following standards and specifications:

Parameter	*Maximum limit (mg/liter unless otherwise noted)*	
	Sewage effluent	*Industrial Liquid Effluent*
Temperature	35°	35°
PH	6-9	6-9
Biochemical Oxygen Demand	60	60
Chemical Oxygen Demand	80	100
Chemical Oxygen (Permanganate)	40	50
Dissolved Oxygen	Not less than 4	-
Oils and grease	10	10
Dissolved Solids	2000	2000
Suspended Solids	50	60
Colored Substances	Free of col. sub.	Free of col. sub.
Sulphides	1	1
Cyanide	-	0.1
Phosphate	-	10
Nitrate	5	40
Fluorides	-	0.5
Phenol	-	0.005
Total heavy metals	1.0	1.0
All pesticides	nil	nil
Total Coliforms (MPN/100ml)	5000	5000

In 1994, the government of Egypt issued a new environmental law (Law 4). The Environment Law 4 incorporates the conservation of the environment as a basic tenant. The law is concerned with the three components of the environment: air, soil and water. The law specifies the MPWWR to be the sole authority in charge of protecting the Nile and the waterways in Egypt. Ministry of State for the Environment is responsible for enforcing this law concerning the protection of air and soil. The executing agency to perform the activities related to protection of air and soil is the Egyptian Environment Affairs Agency (EEAA). The law sets the overall responsibilities of the EEAA including coordination between various ministries and authorities with regard to setting priority strategic targets for water quality management. The law also provides general rules for the protection of the environment and regulates the use and protection of the marine environment.

6.2. Pollution Control

As is the case in many other developing countries, the management of pollution control in Egypt is rather fragmented. Some ministries have responsibilities for certain aspects, but there is no overall co-ordination. The result is that prevention, treatment and impact modifying measures are being applied, but they are not implemented on the basis of a common and co-ordinate set of priorities and that not all effluent flows are under control.

The industrial sector is responsible for pollution sources originating from industrial. As mentioned earilier, Law 48 stipulates that only treated effluents that meet specific standards can be discharged to the surface or groundwater system. In practice, few industries have licenses, especially and action against public industries protection, water economics, and sustainability. The policy focuses on increasing the water availability through water saving and conserving measures, keeping water resources and the surrounding environment in good quality, and protecting the country against water resources related hazards (floods and droughts). Several laws and legislation have been issued to ensure the suitability of water quality for each specific use and to control the water pollution. Pollution control is also being achieved by establishing the water quality monitoring network along the irrigation and drainage systems. In the following sections, a description of current actions and efforts carried out by the Government of Egypt concerning the protection of water resources and the conservation of their quality are presented.

6.1. Environment and Water Quality Laws and Legislation

There has been an increasing concern of the Egyptian government for the protection of the Nile and the waterways. This lead to the issuing of several law and presidential decrees in relation to waterways protection from pollution starting by Law93 for the year 1962 concerning the disposal of liquid wastes in public or private waterways. The most important of these laws is Law 48 for the year 1982 in relation to the protection of the Nile and waterways from various sources of pollution. The law establishes the necessary definitions and relationships in the field of water resources. It assigns the Ministry of Health (MOH) to perform periodical sampling and analysis of water, mainly for municipal uses at the intakes of water treatment plants. It also assigns the Ministry of Public Works and Water Resources (MPWWR) (formerly Ministry of Irrigation, MOI) to issue licenses for discharging or discarding solid, liquid, or gaseous wastes from commercial, industrial, or tourist properties, shops or establishments or from sanitary drainage and other operations into the waterways. The law also assigns MPWWR for issuing permits for constructions producing wastes to be discharged in the waterways.

In Chapter 6 the law sets the standards and specifications for discharging treated liquid effluents into waterways. Article 60, which is listed in Table 2, sets the standards and specifications of fresh water bodies in which treated industrial effluents are discharged. Article 61 specifies the maximum permissible limits of various pollutants set by the Ministry of Health for discharging treated industrial effluent into fresh water bodies or groundwater aquifers. Also, the standards for drainage water quality to allow mixing into fresh water bodies and reuse in irrigation are presented in Article 65. Maximum limits for different parameters in sewage and industrial effluents to be discharged into brackish and saline surface water bodies are listed in Article 66 (Table 3), while the standards for these water bodies to receive such effluents are stated in Article 68.

contributes to salinity build up and is toxic to many forms of live stock and wild life once digested. High heavy metals concentrations are more likely to be found in sediments because once discharged they rapidly settle to the bottom of the drains.

Industrialization is now taking place in the short term in new desert areas around main cities, resulting in an increase in the volume of effluents and toxic wastes discharged into the groundwater system. This situation calls for the implementation of pollution measures for the existing industries, and information and monitoring systems for this growing industrialization.

5.2.1.3. Agricultural Drainage

The major effect of agricultural activities on water quality in Egypt can be considered to be changes in salinity, deterioration of water quality due to the excessive use of pesticides and fertilizers, and eutrophication of water bodies due to increases in nutrient loading. Obviously, part of the fertilizers is drained into the surface water system, either directly or indirectly by groundwater infiltration. Agricultural pollution from pesticides, herbicides and fertilizers affects water system, soils and health of the farmers. It may also have a direct toxic effect on food supplies. Not only surface water is effected by agricultural activities, but also groundwater pollution may occur as well. Hence, the use of this source, for example for drinking water supply, is at risk. Therefore, agriculture can be considered as a widespread non-point source of pollution. Usual pollutants comprise leached salts, nutrients and a great variety of pesticides.

In Upper Egypt, more than 4 bcm of drainage water return back to the Nile River. ·This drainage water has a salinity of 400 to 800 mg/l but with the high mixing ratio of the Nile to drainage water, the salinity drops to acceptable limits. Typical salinity values at the High Aswan Dam are in the order of 150 mg/l and increase along the river till it reaches 250 mg/l at Cairo. The situation is different in the Delta as water salinity in irrigation and drainage canals increases because of intensive agriculture, domestic, and industrial pollution. Typical levels of salinity for water pumped into the Mediterranean and the northern lakes are between 2000 and 3000 mg/l. However, more than 50% of the drainage water has a salinity level less than 2000 mg/l and can be potentially reused for irrigation with proper mixing.

Bahr Hadus is one of the major drains in the Nile Delta region. It runs in the eastern Delta and its water is pumped into Lake Manzala. It is expected that the drain would provide about 2.0 bcm of water per year for reuse in El-Salam Canal. The canal is implemented to irrigate a large agricultural area in northern Sinai. Figures 6a, b, c, d show the major anions analyzed from monthly samples (usually 12-15 samples per month) of drainage water at 8 pump stations providing Bahr Hadus drain with it water during 1992/93. The figures show higher concentrations of all anion in February, as it is the month when all canals are closed for annual maintenance. However, concentration levels during the rest of the months fall within the permissible levels for water reuse after mixing at a ratio 1:1 with canal fresh water. Figures 6e, f, g, h show the major cations at the same pump stations in the same year. The monthly variations of different cations are insignificant except for February because of the winter closure.

Recent figures of the application of nitrogen, phosphate and potassium fertilizers in Egyptian agriculture show the increase of nearly 4 fold during the 1960 to the 1988 period. A wide variety of pesticides, which are mostly imported, are also used in from water pollution generally because of domestic, industrial, and agricultural activities.

5.2.1.1. Domestic Waste Water

Large cities are generally equipped with water supply and sewer systems and have some sort of treatment. At present, there is a significant expansion in water supply networks in several towns and villages, without parallel construction for new sewage systems or rehabilitation of the existing ones. Hence, serious problems of water pollution are anticipated as the majority of villages and rural areas still lack wastewater collection or treatment system. Currently, most of the municipal and rural domestic wastewater is discharging directly into the waterways without treatment. The discharges are increasing year after year due to the population growth as well as the rapid implementation of water supply networks in many villages.

The constituents of domestic and urban input to water resources are pathogens, bacteria, nutrients, suspended solids, salts and oxygen demanding materials. According to a prepared report by the World Bank in 1993, approximately 65% of the Egyptian population are connected to drinking water supply and only 24% are connected to sewage services (Table 1). The population not connected to sewerage systems relies on individual systems such as latrines, septic tanks, or directly discharge their raw waste into nearby open waterways (drains and canals). Several projects are being executed to implement water collection and disposal networks in all governorates. There are also plans aiming at having full treatment of wastewater. However, actual implementation is constrained by financial boundary conditions.

Table 1 Service levels for water supply and sewerage (World Bank, 1993)

Area		Population		% of population served	
		millions	%	Water	Sewerage
Cairo		11.1	20	95	77
Alexandria		3.3	6	98	40
Canal cities		1.1	2	96	35
Other cities		8.5	16	80	30
	Total urban	24.0	44	90	50
Rural villages		31.0	56	45	3
	Total	55.0	100	65	24

The table shows that Cairo has the highest sewerage coverage in the country. Alexandria comes second with only 40% of its population connected to sewerage. Sewerage services are very low in small towns and rural villages. The expected population growth calls for high investments to prevent a further deterioration of the overall water quality situation. It has been detected that population growth is strongest in the Greater Cairo region. Hence, collection and treatment of wastewater in this region is of special concern.

An extreme example of domestic pollution is the Bahr El-Baqar drain in Eastern Delta. The drain receives a large concentrated discharge of only primary treated wastewater that causes a serious pollution of this drain. The pollution load ends up in Lake Manzala and affects significant the lake environment. Despite the 170 km length of the Bahr El-Baqar drain, anaerobic water is found at its downstream end near Lake Manzala. In spite of the poor water quality, the drain water is reused for

1) the non-renewable Moghra aquifer in the Western Delta;
2) the coastal aquifer system fed by rainfall along the northern and western coasts;
3) the karstified carbonate aquifer system overlying the Nubian sandstone aquifer in the north-middle part of the Western Desert; and
4) the fissured and weathered hard rock aquifer predominating in the Eastern Desert and Sinai.

4. NON-CONVENTIONAL WATER RESOURCES IN EGYPT

Demands for water and arable land continue to rapidly increase due to population pressures, industrialization, and requirement for food production and employment generation. The availability of water for various uses is limited and is quickly reaching scarce levels. Reuse of agricultural drainage water for irrigation has become an inevitable choice for Egypt as the future demands is expected to exceed the available fixed fresh water resources. Reuse of drainage water in the Nile Delta has been adopted as an official policy since the late seventies. The policy calls for recycling agriculture drainage water by pumping it from main and branch drains and mixing it with fresh water in main and branch canals (Abdel-Dayem, 1997). Figure 4 exhibits the comparison between annual amounts of drainage water pumped into the Mediterranean and the northern lakes and annual amounts of reused drainage water during the period 1984/85 - 1997/98. The figure exhibits a decreasing trend in the amounts of water pumped into the sea with a significant increase in the amounts of drainage water reused during the same period.

It is worth mentioning that there are two major projects currently undergoing to increase the amount of drainage water reused. The first project is expected to utilize 2.0 bcm per year that will be directed to El-Salam Canal to irrigate the northern Sinai area. The second project is going to divert 1.0 bcm per year from Umoum drain for land reclamation projects in the Western Delta region.

In large cities in Egypt, there are few treatment plants for the collected domestic wastewater. Currently, there is a volume of about 1.0 bcm of primary treated wastewater that is being used in irrigation in specific locations outside the Greater Cairo region. It is expected that by the year 2000 this volume of treated wastewater will reach 2.0 bcm.

In addition to the above mentioned non-conventional water resources, desalination is being used to provide domestic water supply for some locations along the Red Sea coast and in Sinai Peninsula. The capacity of the desalination plants in Egypt is only about 0.8% of the total desalination capacity in the Arab World. Currently desalinated water use is only limited to municipal use due to its high cost of production. Nevertheless, renewable energy sources are being investigated as they are considered promising sources for energy for large desalination projects.

5. ENVIRONMENTAL PROBLEMS RELATED TO WATER RESOURCES

Like in most developing countries environmental problems have received little attention in Egypt in the past. However, with the increasing population and intensified human activities, protection and management of water resources of the country is a subject receiving an ever-increasing attention. There are several key problems in relation to water resources. They are 1) Scarcity of water resources, 2) Water pollution, and 3) Impact of climatic changes on water resources.

of the country. The formulated policy focuses on three major aspects: demand management, resources development, and environmental protection.

2. NEW PARADIGM FOR POLICY FORMULATION

The sustainable development of water resources planning and management can be achieved by a genuine commitment to a) protect ecological integrity and equilibrium to ensure a healthy environment; b) support a dynamic economy; and c) achieve social equity for present and future generations. Agenda 21 has indicated the need for tools and techniques for multiple objectives' evaluation and planning. The multiple-objective concept stipulates that national, regional and local economic development, environmental quality and sustainability, social well being and quality of life are critical issues that have to be dealt with in its context. Moreover, the sustainability concept relies on maintaining the trade-offs between interests of the present and future generations without having to compromise what is currently under control (SRU, 1998).

Efficient and effective use of all water resources in Egypt in both time and space requires the formulation and implementation of appropriate water sector policies. Formulation of Egypt's water resources policy for the 21st century requires a major shift from the classical paradigm used in resources planning and management to a new innovative paradigm (Abu-Zeid, 1997). Dynamic inter-relationships among water resources system components impose the integrated approach on policy makers. A multi-disciplinary dialogue has to be adopted in the policy formulation process. The development of such a long-term national policy means extended planning horizon and wide spatial coverage that leads to high uncertainty. Furthermore, increasing environmental awareness and quality deterioration of the limited fresh water resources necessitates the replacement of water quantity management by quantity and quality management.

Sustainable water resources management and development are correlated with an ecological matrix that includes soil, water, fauna, flora and human beings. Formerly, the low rate of socio-economic development and the small population resulted in overlooking the environmental issue. On the other hand, the accumulative nature of the adverse environmental impacts, the ambitious socio-economic development plans and the inflating population dictate that the environmental aspects need to be equally treated with respect to the socio-economic needs in the Egyptian water policy. Several environmental problems loom large, including scarcity of water resources, water quality deterioration, and uncertainties about the impacts of global climatic changes and possible conflicts over shared fresh water resources. This paper is to provide an overview of the current water resources status, the environmental and water quality issues, and the MPWWR efforts to overcome these environmental problems of water resources in Egypt and to present the national actions adopted to reinforce sustainable water management development.