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Environmental Standards related to Project of Waste Water Collection, Treatment, Proposal and Reuse

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ENVIRONMENTAL STANDARDS RELEATED TO PROJECTS OF WASTEWATER COLLECTION, TREATMENT, DISPOSAL AND/OR REUSE.

By

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Abstract

Carrying out a study or executing a project for wastewater collection, treatment, disposal and/or reuse including planning, investigation, design, construction, utilization, operation, maintenance, environment protection, monitoring and evaluation requires a certain set of specifications, norms, standards, codes, guidelines, regulations, policy measures and legislation (laws and bylaws) which have to be followed in order to ensure efficient development, management and proper utilization of wastewater reuse including environment protection based on factual assessment of water resources (quantity and quality) for various uses i.e. domestic, industrial, agricultural. The relevant national policy documents in the form of Water Strategy, Water Utility Policy and Irrigation Water Policy as well as National Standards relevant to the prevailing climate conditions have to be developed, taken into consideration and adhered to as much as possible.

Enforcing standards for wastewater discharged to sewers and for irrigation is essential. Many countries have adopted international water quality standards /guidelines or values/norms developed by the WHO, FAO, EPA, and other prominent organizations and agencies. However, to achieve a desirable water quality, it is not always suitable to adopt these standards depending on existing local conditions. When water is extremely limited, water standards must be carefully examined to assure that available water resources are fully and efficiently utilized. Thus, the standards adopted should consider national priorities, economics and availability of water supplies as well as health and other environmental factors. Setting of standards and enforcing their implementation require financial affordability, commitment, coordination and collaboration among concerned agencies and at all levels without jeopardizing public health. Adopting and implementing standards for treated wastewater effluent will minimize health hazards and environmental risks such as biological and chemical pollution of water sources, and also would increase the availability of water for irrigation. To ensure that these standards are achieved, an efficient monitoring and evaluation programme has to be effected. Development of a national wastewater strategy and policy should include standards for proper collection, treatment, disposal and/ or reuse, taking into account the health risks that could be involved in the cultivation, harvesting, and consumption of crops. To protect human health and the environment as well as to ensure additional water supply that meets the appropriate standards for its disposal or use, the concerned organizations have to ensure that appropriate wastewater collection systems and treatment facilities are provided for all sources of wastewater where feasible. National Standards for treated wastewater effluent for different uses are sometimes stringent "based on the worst case assumptions" or conditions which may not be relevant to the local conditions or even affordable in some cases.

Key Words: Wastewater - Treatment, Disposal, Reuse, Pollution, Monitoring, EIA, Standards, Legislation, ESCWA.

1. Introduction

Water resources are currently over exploited in many ESCWA countries and irrigation accounts for about 70% of all water use. The scarcity of water and the ever increasing requirements to meet and sustain the needs of irrigated agriculture, the growing population at the annual growth rate of 2.5 –3.5%, the urbanization and the expanding industries necessitate an efficient management and conservation of available fresh water and reclaimed wastewater. This has become one of the national priorities in most of the ESCWA countries and many countries call for reclaimed wastewater reuse. National water strategies in many countries include the use of marginal quality water sources to support irrigated agriculture .If a significant percent of the effluent would be treated and reused, this would rebound positively on the public health, new infrastructure, the productivity in the sector which profits from the reused water, and the quality of water discharged into rivers, wadis and aquifers.

However, the projected works involve a very significant financial investment that will need a long time to be amortized, but this investment could be one of the keys to assure the future .The improvement in other sectors must act as a balancing entry to obtain short – term benefits.

To minimize capital and operation costs, the treated effluent is used in existing systems where available and not transported over long distances. If it is possible to utilize the treated effluent stream in existing irrigation systems this will require the minimum additional capital cost .The treated effluent may be used to either replace or supplement the existing source of irrigation water. If it is not possible to utilize an existing irrigation system then a separate dedicated irrigation system may be provided. Wherever possible, the effluent should be re-used as close to the treatment plant as possible to minimize capital and operation and maintenance costs of the conveyance system .If practical reuse option is not available then the treated effluent will be discharged to wadis or rivers thus supplementing current surface water or groundwater.

Where reuse is practiced, the sale of treated effluent for irrigation with either partial or full recovery of the marginal cost for additional treatment, storage and conveyance is an option, subject to the willingness of consumers to pay for the water. However, it is likely that the true marginal cost will need to be heavily subsidized, at least until the practice of using treated effluent is accepted and the cost of water from other sources rises to comparable unit price.

"The current water crisis in the Middle East region is a result of the over use of available resources .In economic terms the crisis is therefore mainly a problem of demand and in its spatial dimension a regional challenge. Potentially magnifying the demand pressure on the water system is the specter of **Global Climate Warming** that could reduce the available supply. In general; there is a great uncertainty about regional impact of that global transformation. However, if it occurs, climate warming would affect the water supply situation in the Middle East region in three ways: **Firstly**, in the subtropics, to which the region belongs, temperatures are likely to rise above the average. According to (lonergan and Kavanagh, 1991) who surveyed a number of climate models, temperatures in the region are forecast to rise between 15 and 30% above present levels. This would increase evaporation rates by 5 to 20% exacerbating water losses from reservoirs, open conduits and in agriculture, and augment demand for domestic and recreational consumption. **Secondly**, precipitation would probably decline (although the climate models are not consistent in their precipitation projections for the region). This would have obvious implication for the amount of water supplied to replenish streams and aquifers. **Thirdly**, the viability of the precipitation might change; resulting in even more accentuated extremes between dry and wet periods. Changing climate would furthermore pose great challenges to international agreements on water distribution which may be concluded among the riparians of international water bodies. Traditionally, such treaties stipulate water amounts or quotas to be allocated to the parties involved. This is done on the assumption that the climate will remain stationary i.e. variable in the short term but unchanging overtime. Indeed, hydrologists and lawyers have few tools with which they can incorporate future changes of uncertain magnitude .A decrease in flow could make achieved agreements obsolete and revive old conflicts (Libiszewski, 1995). The impact of climate change on the physical, chemical and biological processes of rivers and water resources as well as the agroecological characteristics in the Middle East countries have to be evaluated accordingly.

In arid and semiarid countries such as most of the Middle East countries, finite water resources and existing over – abstraction from some aquifers reinforce the need to make the best practical use of treated wastewater effluent to augment existing water resources available in these countries. Wastewater shall not be managed as "WASTE"; efforts should be made to ensure that treated effluent is reused.

Institutional development, training, economic and financial analysis, demography, hydrology, geology, hydrogeology, soil conditions, topography and environmental studies normally form major parts of the study phase of wastewater collection, treatment, disposal and/or reuse projects

2. Uses of Reclaimed Wastewater

After exploiting all remaining natural water resources, a supply – oriented water management strategy will go on to develop new resources. The first promising source is unconventional and technology – intensive supply which consists of purifying and reusing treated industrial and domestic wastewater .It is assumed that about 65% of the water consumed by industry and the households can be recycled if collected by sewerage systems and properly treated. At present, between 20% and 30% of total water consumption in the countries of the Jordan River Basin is attributable to the domestic and industrial uses (Libiszewski, s. 1995). This share is likely to increase rapidly as a consequence of population growth, improvement of living standards and economic development. It is also estimated that in the year 2023 the Palestinian Territories will have available

some 325 MCM/year of wastewater (this figure presupposes, however, that in the future the Palestinians will get a substantially larger share of their waters that are being exploited by Israel). With similar standards applied to Jordan, 500 MCM/year of wastewater will be produced. Without fully developing these unconventional resources, there will be only small quantities of endogenous water for agriculture. Throughout the ESCWA region, wastewater reclamation has a great expansion potential. In the Palestinian territories most cities and all villages still lack sewerage systems to collect wastewater, although such systems are presently under construction in some towns .In Jordan, sewerage systems and treatment plants have been built or are under construction in most towns. However, a minor part of that is being purified. It was expected that treated wastewater reuse would provide about 45 MCM/year for irrigation by 1995. Compared to some 230 MCM/year of water consumed in the domestic and industrial sectors, this is an amount which still leaves a great potential to be exploited.

Reclaimed wastewater can be used for irrigated agriculture (fiber, seed crops, vegetables, diary pasture, hay and alfalfa, orchard, vineyard and frost protection), industrial uses (cooling of factories, boilers, stock feed) groundwater recharge by pumping down / injection of treated wastewater in wells, abatement of salt – water intrusion, land – subsidence control and spreading on sandy areas. Non potable urban uses by reclaimed wastewater include landscape irrigation, fire fighting and protection, toilet flushing, commercial air conditioning, vehicle and street washing and commercial home laundry. Treated wastewater can be used also for streamflow augmentation, marches, wetlands and fisheries /aquaculture, construction and dust control.

Moreover, apart from largely solving environmental problems arising from dumping untreated sewage into natural water bodies or the landscape, recycled wastewater also contributes important nutrients to the soil. Thus, it can obviate addition of commercial fertilizers and organic matter to irrigation water. Taking into account these beneficial side effects, recycled wastewater is one of the least expensive and most attractive unconventional sources of water for agriculture. However, the technique requires high investments and must be applied with caution, since inappropriate treatment and/or use can harm the quality of soils and human health.

In a water–short environment, reclaimed wastewater constitutes an integral part of the available water resources and national water policies should recognize its importance. Therefore, it is essential that the necessary reclamation and reuse facilities be developed .The primary objectives of these facilities are to: (i) prevent the discharge of untreated or partially – treated sewage into the environment in order to mitigate potential adverse impacts to human health and the environment in general, and (ii) augment and sustain available and environmental resources. These objectives would be achieved by: (i) collecting and transporting sewage from all points of production to treatment facilities by methods which are economically and technically sound, (ii) controlling the discharge of raw sewage into the environment, particularly into sensitive water resources, (iii) limiting the number of discharge points of treated sewage, (iv) facilitating optimum use of treated sewage, and (v) applying appropriate sewage and sludge treatment technologies taking into account both quality requirements for reuse, disposal and economic sustainability.

The acceptability of reclaimed wastewater for any particular use mentioned here above depends on social factors and the physical, chemical, and microbiological quality of the treated wastewater. Factors that influence the quality of reclaimed wastewater include the quality of wastewater source, collection system design, wastewater treatment reliabity and operation and maintenance. Economic concerns of reclaimed wastewater use need to be assessed especially where the water supplies are scarce . Appropriate wastewater treatment technologies have to be adopted with due consideration to economy in energy consumption and quality assurance of the treated effluent for reuse as will as consideration shall be given to dualing and blending of treated effluent with fresh water for proper reuse.The existing standards (local and international) and the guidelines of the WHO and FAO suggest treatment processes to meet health criteria for the above mentioned uses of reclaimed wastewater.

Many benefits such as raising the sanitation levels, improving public health and pollution control of surface water and groundwater are realized when wastewater collection and treatment systems are implemented .One major problem facing most of the existing WWTP's is receiving domestic wastewater with high strength in terms of BOD5 (500 – 1500 mg/l). This is attributed to the low water consumption. Water shortage also imposes several operational problems and some existing plants are being biologically over loaded with only a portion of their hydraulic capacity. Other WWTP's are hydraulically over loaded due to increase in amounts of effluent discharged to the plants.

While wastewater treatment and reuse play a significant role in quantitative substitution for diversion of agricultural fresh water to municipal use, it does not, on its own, constitute a substantial source for expansion in agricultural production .It is estimated that the treated effluent of a community would barely be sufficient to grow more than 10% of its needs of agricultural production.

Analyses were undertaken in Jordan in 1998 to assess the incremental marginal cost of providing additional treatment and conveyance structures to render the effluent suitable for irrigation. For new schemes the incremental cost ranged from U.S.$ 0.1 to $0.42 /$m^3$ and averaged $0.19/$m^3$. This is almost seven times the price being paid by users for irrigation water from other sources (maximum $ 0.03/m^3 up to 3000 m^3/month charged by the Jordan Valley Authority, JVA in Jordan). With the projected population increase at the year 2020 it is predicted that the average marginal cost of $ 0.19/m^3 will drop to around $0.13/$m^3$. A study based on the Israeli experience indicates that the cost of conveying and treating wastewater effluents amounts to between U.S.$0.26 and U.S.$0.52 per cubic meter (Ben Gurion University of the Negev and TAHAL Consulting Engineering of Israel, 1994).

3. Water Quality Monitoring

Water quality and quantity constraints and challenges include the pressure of high population growth rate, over abstracted aquifers, industrial pollution, overuse of agrochemicals (pesticides, insecticides, fertilizers, etc.) drainage water, overloading of wastewater treatment plants, seepage from land fills and septic tanks and improper disposal of dangerous chemicals by some economical activities which affect the water resources in particular and the ecosystem in general.

Water quality indicators include chemical, physical and biological properties which affect standards and tolerances for various uses of water. However, meeting these standards can be difficult and complex .Treated effluent from WWTP's entails a different set of challenges .The performance of many of the existing plants is inadequate due to overloading which results in effluent of low quality. This effluent may have an adverse effect on public health due to the presence of pathogens or the accumulation of toxic elements in irrigated soils. Furthermore, pollution of water sources will limit their use for drinking purposes. The quality of wastewater effluents and the performance of WWTP's are normally affected by the influent quality which might be domestic and/or industrial sources.

High –Salinity levels of irrigation drainage waters preclude their reuse in agriculture and their sources should not be combined with municipal wastewater flows, as the salinity will inhibit treatment plant performance. Low-salinity sources have a potential for direct reuse. Options for removal of salinity by reverse osmosis or ion – exchange are not considered to be economically viable. It is normally recommended that available funds should be directed to the provision of tertiary treatment at municipal wastewater treatment plants which will provide approximately five times the yield per unit investment.

The impact of solid waste and industrial wastewater in the urbanized areas should make decision makers alert to implementing incentives before penalties, regulations, monitoring and controlling facilities that allow discharge of sufficiently treated wastewater with less index value of toxic discharge per unit of available water. In semiarid countries with scarce water resources there is a major potential for pollution by industrial water when industrial activities increase. The solid waste dumps should be provided with protective land lining against potential leaches .The landfill sites should receive controlled /monitored liquid source in order to avoid groundwater contamination and proper facilities should be provided for adequate disposal of hazardous waste of industries. National Standards and guidelines for industrial wastewater treatment and for connection to the public sewerage networks are essential components of a long – term strategy for regulating industrial wastewater.

Water quality criteria for the physical, chemical and biological characteristics which reflect tolerances and requirements for various uses are essential components of a national water utility policy. These characteristics should reflect human health considerations and people's intangible sense of aesthetics. When these values are incorporated into enforced standards, the result will be water that is both aesthetically pleasing and reliably safe. Water of this standard is the right of all citizens and the responsibility of the government.

The monitoring programme requires knowledge of analytical methodology, equipped laboratories and qualified staff for collection of samples, testing, analysis, continuous evaluation and updating of standards and guidelines for the different uses in order not to endanger the environment, public health and the consumers. Particular attention needs to be focused on adopting and enforcing effluent and sludge standards from municipal and industrial WWTP's as well as discharge from hospitals,

factories, laboratories and other economical activities .The most important water quality indicators for irrigated agricultural system (water, soil, plant) are shown in the "FAO Guidelines for Interpretation of Water Quality Data, 1988", "WHO Standards", the "American National Technical Committee Guidelines, 1968 ", and the plant –salt tolerance considerations .The consequences of soil – salinity increase beyond crop tolerance due to use of insufficiently treated wastewater discharged from overloaded WWTP's compounded with trace elements from industrial pollution, insufficient leaching and the use of pesticides and fertilizers, etc. have caused irrigated land to become out of production, loss of jobs and loss of revenue in some countries .Clogging of drip irrigation emitters due to the biology growth inside the irrigation pipes near the emitters explains the intrusion of organic materials and other constituents as Fe and H_2S .The FAO guidelines restrict using the drip irrigation method when the THBC is greater than 50000 CFU / ml. Most water uses are associated with return flows, these range from wastewater collected in an urban sewer system to irrigation return flow percolating into groundwater tables (drainage water) and those discharging in a nearby collective drains or contact springs.

4. Water Pollution

The water crisis in the Middle East region has been described mainly as a problem of quantities. However, a quality problem exists, too. As far as salinization of water resources is concerned, both problems are closely interconnected. Intrusion of saline sea or brackish water into the fresh water table and increasing salinity of some surface water bodies (lake Tiberias) are caused by quantitative over - exploitation of scarce resources. Also, other sources of pollution endanger fresh water supplies of the region as well. The major non- – point source of many pollutants is agricultural runoff, which includes sediment, phosphorous, nitrogen, and other chemicals. The warm climate and prominence of agriculture in the economics of the region help to make use of fertilizers and pesticides widespread. In most of the countries, legislation regarding use of agrochemicals is rather lax, resulting in a per hectare use of pesticides and fertilizers which rates among the highest in the world. Correspondingly high is the agricultural run-off flowing into streams or seeping into groundwater (Libiszewski, 1995).

"The situation is even worse in the Palestinian Territories where mechanisms of control and monitoring do not exist and knowledge about proper use of chemicals among farmers is insufficient. "The result is the routine and heretofore virtually ignored contamination of Palestinian food, water and the environment posing a menace to farmers and consumers alike" (Hosh et.al 1992). The problem is most acute in the Gaza Strip but exists to a less extent on the West Bank"(Libiszewski, 1995).

Municipal and industrial sewage effluents are another source of pollution. Dumping is common in all countries of the region, often directly into watercourses or into wadis, which, at the next rainfall, allows contaminants to seep into underlying aquifers. A typical example is the Zerqa River in Jordan. It rises near the capital, Amman and receives effluents from its industrial suburbs before entering the King Talal reservoir. It is intended to provide water to irrigate the lower Jordan valley during the summer months. A treatment plant, Waste Stabilization Pond (WSP) in Kherbit As – Samra is supposed to decontaminate the water. But, misconceived and too small in size, the plant did not afford its purpose. Silt and other pollutants accumulate in the artificial lake. During years of drought from 1988 – 1991 this led to a situation in which the authorities were forced to prohibit use of water from the reservoir (Libiszewski, 1995). This situation has improved recently by modifying and expanding the WSP. Another example is the discharge of industrial and domestic wastewater from the Israeli settlements into the wadis of the Palestinian territories.

5. Global Proposals For Significant Environmental Impacts

The Environmental Impact Assessment study (EIA) normally forms a major component of a project related to wastewater collection, treatment, disposal and/or reuse .The EIA study is undertaken in developing countries such as ESCWA member states in accordance with national and international standards, the European Community (EC) standards, the U.S.AID standards, the World Bank Guidelines, or the standards of the donor countries .The environmental impacts (significant, long – term and short term) and their mitigation measures and monitoring plans include : surface water, groundwater, flora, fauna, natural habitats, wild life, energy, noise, dust, odor, human health, human habitat, infrastructure, solid waste, hazardous waste, sludge disposal, soil salinity, toxicity, heavy metals, agriculture, land use, employment implications, town planning, cultural heritage (archeological, historic) tourism, public perception, use of pesticides, insecticides, and fertilizers, fire protection, and safety. Overall, the project is assessed to have a very positive environmental impact, achieving significant

improvements in public health and the environment by ensuring that potentially damaging waste is collected, treated and where possible the products reused to conserve valuable natural resources. It is accepted that in a situation where the immediate environment to a property is improved, there is an increase to the value of that property. However, it is difficult, if not impossible, to quantify this increase. The main environmental impacts are:

5.1 Public Health

The overflows from cesspools, having pathogen microorganisms, cause a serious threat. Cesspools can also pollute the ground water aquifers used to extract potable water. Besides, some wastewater is discharged to natural surface water flows. Diseases such as diarrhea, typhoid, paratyphoid, hepatitis "A" or even cholera can be contacted directly from water. Many internal parasites such as helminthes and nematodes are easily transmitted through wastewater. Deficient quality of water for drinking or for washing fresh vegetables could lead to a quick spread of cholera. Other diseases such as malaria and leshmanosis are contacted through dipterous which act as vectors .The first part of the vital cycle of Anopheles, an unusual vector of malaria, and other vectors have a place in stagnant water and so, the different lagoons and ponds used in the wastewater treatment can be very convenient for their spreading reproduction. Domestic wastewater from existing collection systems may mix with the domestic water due to infiltration and other failures in the water supply conveyance and distribution networks .The presence of fecal coliform in water is a clear indication of contamination by human waste and high levels of nitrate can also be caused by fertilizers.

The WWTP's have to be provided with suitable security fences to keep away children and intruders .The health and security of the operation staff must be guaranteed through training and the application of a specific **Safety Plan** which needs to be periodically updated. Proposed standards of quality for treated waters will fulfil the sanitary conditions to allow the wastewater usage to irrigate vegetables, fruit trees and crops taking into consideration the limitations usually noted for prevention of hazards. Mosquitoes can spread from some WWTP processes, especially from drying beds; this is another reason to place them far away from inhabited areas.

Regarding the safety of a specified sewerage treatment plant, any possible danger on the health of residents or the farmers in the vicinity should be negligible .As a result of such projects, new sewer networks would increase the number of houses served, thus reducing the cesspools and any other undesirable ways of wastewater disposal and in turn reducing water born diseases. The impact is significantly positive on the short - term and long –term Health benefits in terms of reduced medical care and improved productivity are important factors in addition to the other interventions mentioned above. However, it will be difficult to isolate and quantify any single intervention in the water supply and disposal cycle. Health impact studies have rarely been designed to isolate health improvements due to one element of this cycle and it is difficult to determine the extent of one influence (clean water, sanitation, health, education, etc.) over another .The financial sanitary cost of four waterborne illnesses (diarrhea, amoebic dysentery, typhoid and paratyphoid, and hepatitis A) has been evaluated in Jordan (1995 data) giving a total of JD 8000 per 1000 people, without taking into account loss of working time and other expenses.

5.2 Irrigated Agriculture

The salinity of soils imposes important restrictions to the cultivation of most of the species of an agronomic interest. High concentrations of salt cause significant decrease in crop efficiency, even stopping cultivation. When the electric conductivity of the soil saturation extract (CEe) exceeds 4 mmhos/cm, the soils are slightly saline while soils of CEe, which exceeds 16 mmhos/cm, are considered extremely saline. On the other hand, high contents of salt provoke alteration in the soil structure, limiting its capacity of cationic interchange and what is worse, accelerating the erosive processes. This is the case of the sodium or salty sodium soils in which this cation replaces the hydrogen raising the pH up to 8 or even higher. In these cases the nutritive elements of the soil; N, P, K, change into forms non – assimilated by the plant and other elements which in conditions of a lower pH are non - toxic turn into toxic. Apart from the nutritional problems produced by the salinity, there are other ones related to the water (hydric) stress provoked by increase of the osmotic potential. When this value exceeds a certain limit, the plant enters a temporary withered state and if the situation continues, a permanent withered state. High osmotic potential, although not reaching the limit values, causes decreases in the productivity. In the same way, long stress situations can increase the incidence of plagues and diseases. Saline soils are common in zones of arid and semiarid climate. They are usually "infrazone" soils in which the drainage is scarce. The intense evaporation produces the concentration of the soil solutions and the product of solubility of sulfates and calcium carbonate is quickly reached, these hurl down, leaving chloride and sodium ions in the soil solutions.

The salinity of the soils may be caused by the different factors which operate either separately or jointly .The causes include the contribution of rain water which produces a phenomena called "Cyclic Salinization", the geologic nature of the ground which contributes to the increase of groundwater salinity, the extraction by over pumping of the aquifers which may provoke the rise of deep layers of water with higher levels of salinization and the methods of irrigation. Nitrate is the main indicator of organic or inorganic pollution .It is very soluble in groundwater and presents a great mobility. The increase of nitrate concentration is caused by the massive use of nitrogenous fertilizers, especially urea, and dumping of ammonia by wastewater treatment plants, which is anaerobically oxidized to nitrates .The reuse of treated wastewater for irrigation could cause a significant negative impact on the soils if proper measures for saline soil rehabilitation are not applied.

The Environmental Research Center (ERC) of the Royal Scientific Society (RSS) in Jordan conducted a study to investigate and determine the possible causes of the tomato crop failure that took place in the central zone of the Jordan Valley in 1990 – 1991 growing season for areas irrigated completely or partially by King Talal dam which is polluted by domestic and industrial effluent. The study investigated various components of the crop production including the management of land and water resources, management practices at the farm level and their suitability, problems associated with the nurseries and their impact on spread of diseases, soil and plant analysis as well as water quality and quantity analysis .The technical evaluation of the study revealed the following:

... Pathogens could be responsible for up to 65%of the crop failure.

... Soil salinity, inherent or as a result of long –term irrigation could be responsible for up to 25% of the crop failure.

... Water quality could be responsible for up to 10% of the crop failure.

5.3 Water Resources

Scarcity of water is one of the most pressing handicaps for overall development in water – short countries. Per capita water consumption in many ESCWA countries in comparison with the U.S.A. or Europe is among the lowest in the world and water resources are overexploited. Thus, obtaining more water and improving its quality are essential and unavoidable needs. The situation will get worse if population growth continues as currently foreseen and if standards of living, with associated increase in water use, continue to improve as it is normally desirable.

The basic objective of wastewater reclamation project is to prevent the discharge of untreated wastewater into the courses of rivers and wadis .To achieve this, it is proposed that wastewater produced by communities is collected by sewer networks and conveyed to wastewater treatment plants for treatment to a level that will allow its reuse for unrestricted agriculture. Reducing the incidence of pollution of both surface water and aquifers by the discharge of treated wastewater, and the production of treated wastewater to a level suitable for agricultural or industrial use which allows the substitution of treated wastewater for sources currently used for agriculture shall contribute to efficient management of natural water resources .The sewerage network will solve many current water and sanitary problems. Nowadays, many non- – sewered facilities do not work satisfactorily for technical reasons. For example: when the ground is insufficiently permeable for septic tank effluent to soak away, this leads to surface effluent ponds, and when the population densities are too high thus overloading the soakage capacity of the ground, again leading to surface ponds.

Water availability and water consumption are not regular through out the year in all ESCWA countries. Rainfall and air humidity are higher at cold times, but the need for water supply is lower in that period .In contrast, the requirement for water use in agriculture is highest during hot periods. It is assumed that all of the treated wastewater produced during hot period can be re – used for industrial or agricultural purposes either close to or remote from the treatment plants with the provision of suitable distribution pipe work. Excess treated wastewater produced during cold periods, that is not required for agriculture use may be discharged to wadis or rivers and thus would not be available for reuse .To enable this, storage reservoirs for water to be reused could be a feasible option. Alternatives to storage of the possible treated wastewater surplus in cold times /winter season are to store in existing dams, in closed deposits, in aquifers by any injection system, or to discharge to wadis or rivers allowing natural drainage.

Projects for collection, treatment, disposal and / or reuse will have sufficient positive impact, both in the short - term and long - term on water quality and availability. Providing storage for possible winter treated wastewater surplus is usually expensive in the short term but the provision of storage allows management of water resources that may be profitable in the long term.

5.4 Habitat And Wildlife

The highest priority areas such as natural reserves, forests and other sites of particular interest must be avoided when possible .The detailed engineering design of the conveyance network and WWTP's should avoid wood lands or notable tree specimens and large areas of natural vegetation when possible. Well preserved – aquatic ecosystems, as a very scarce and vulnerable habitat, should remain completely untouched .If necessary to trench across territories of endangered species or near preeding bird colonies, it will be important not to disturb them by selecting a work schedule avoiding the reproductive season. Catalogued territories as "important bird areas", although not necessarily under legal regulations should be considered as mentioned here above. Water quality must be guaranteed when WWTP effluent discharges to natural flows. Survival of many species, such as endemic (meaning exclusive) fish Tilapia gallileae may depend on it .It is recommended that any overhead electrical lines across migratory routes should have visual markers at intervals to minimize risk to endangered birds of large size which may otherwise collide with the invisible lines .New WWTP's should be located as close to populated areas as possible, minimizing trench lengths and damage to the biological environment .It will be necessary to find a balance point considering urban areas and other issues. Rats, mosquitoes and other pests will modify their populations near the new WWTP. Their control might be achieved using sustainable procedures. A characteristic of trickling filters is the proliferation of a small dipterous (fly) named Psychoda which forms large flocks but it is inoffensive.

In the short term (construction phase) negative impact ranging from practically null to significant depending on the characteristics of each zone could be irreversible if new installations affect outstanding natural areas. In the long term, there will be a positive impact on habitats and wildlife if the project execution guarantees the flow of good quality winter water into the wadis.

5.5 Odor

The preliminary design of a new WWTP considers units of processes. To prevent odour problems, the drying beds might be placed far away from any human habitation or tourism resource, although transportation could be more expensive in economic terms. Odor does not seem to be an appreciable problem to wildlife, agriculture or any other issue .If possible, communication roads between WWTP and drying beds should also avoid areas highlighted for restriction and preservation. Maintenance is essential for each process. Both efficiency and lifetime of wastewater installations depend on it as well as odour levels .The accumulation of solids in the pretreatment stage, the fats and greases in any stage or the possible improperly managed biological processes could produce unpleasant smells in a wide range outside the WWTP .In the locations of the plants the dominant wadis or rivers must be taken into account.

Odor from any WWTP is of considerable negative impact, although if it is properly projected and maintained, odor levels must be acceptable even to a very close range. New plants when properly designed will reduce decisively and immediately odor levels .A significant negative impact from odor could restart if installations were over loaded and/or improperly operated and maintained.

5.6 Toxicity

Chlorine used for the disinfection of the final effluent is a hazardous gas which must be stored, handled and used properly to ensure safe operation. There is already extensive use of chlorine in the water and the wastewater sector in most of the ESCWA countries and its use in the installations are considered usually the most appropriate method of disinfection of the effluent under their conditions. The following measures should be adopted to ensure the safe use of chlorine: (i) full safety information and handling and storage instructions to be provided at project implementation stage, (ii) all chlorine equipment to be provided by suitably experienced suppliers, (iii) installation of chlorine systems to be carried out by suitably experienced contractors, (iv) chlorine dosing room to be separated by a gas – tight wall, (v) chlorine detection equipment connected to appropriately controlled extract fans and control louvres to be provided, (vi) only fully trained personnel to be engaged in the handling of chlorination equipment , (vii) adequate personal safety equipment including breathing apparatus to be provided, (viii) emergency shower to be provided outside the chlorine facilities, (ix) all storage containers and chlorination equipment to be used strictly in accordance with supplier instructions, and (x) all chlorination equipment to be regularly checked, serviced and maintained.

5.7 Noise

The installation of WWTP and the excavation of materials must be done at a reasonable distance from inhabited areas, in order to minimize the impact on human population. If there is a possibility that the selected emplacement might be inside a territory of any very endangered animal species or close to some breeding colony of protected birds, it would be necessary to adapt the general work plan .The first stages of the

wastewater treatment process (pre – treatment, and primary sedimentation tanks, etc.) do not generate any noticeable noise unless air blowers are employed in grits removal processes. Suction pumps and any other pump considered, as potential noisy sources, will be either submersible or enclosed into manholes, substantially diminishing noise levels. Motor and impact noise from the grit grab of the clam – shell (dredger) is another source of discontinuous but acceptable noise level .In reference to aeration tanks, turbines are recommended more than air blowers with regard to noise level .If the use of air blowers is proposed for engineering reasons, air blowers must be isolated, even if the installations are located far away from inhabited areas. Workers and visitors must wear ear – protectors inside the isolation structure. Trickling filters are almost noiseless, unless complemented with air blowers or fans. They could be feasible solution up to 30000 inhabitants WWTP. Truck movement inside and outside the plant during the operation stage need not be excessive. In order to prevent noise, the careful maintenance of each device, engine and installation, including the road's pavement is essential.

The negative short – term impact can be significant. Preconstruction and construction stages are the most problematic periods in regard to noise. Complementary labours for carrying, digging, truck movements; hits, welding, etc. could produce disturbances in the adjacent areas. The application of the proposed mitigation measures, as already described, must reduce noticeably this impact from the operation stage onward. Maintenance and adequate management of the WWTP are important to keep the noise down to an acceptable standard.

5.8 Dust

Paved roads are preferred for reducing dust emissions. When the roads are unpaved, it is normal practice to water them periodically. Construction works on site will also inevitably cause dust, but this can be minimized by correct working practices. It is usually assumed that all-permanent roadways for a project will be sealed.

In the construction stage, dust emission could have an impact on any works and on both cultivated and natural vegetation growing on roadsides and in adjacent areas. This negative impact is reversible on a medium - term or long - term depending on the species of plants affected. During the operation stage, dust should not cause any noticeable impact. This impact can be defined as negative, small, short term and reversible.

5.9 Employment

The preservation of agriculture is generally desirable and its loss would be of a significant negative impact. Whenever possible, WWTP's should be sited on non- – agricultural or low – grade agricultural land. When agricultural land is taken out of production there will be a loss of employment for agricultural workers and farmers. However, this will be offset to some extent by significant employment levels during construction activity and by a long – term employment of WWTP's operation and maintenance staff.

As a whole, social balance would be very positive, but in this particular issue, it is important to consider any local population which might be affected. There will be additional employment resulting from these projects which would help to alleviate unemployment during the construction phase where the local contractors would employ local labour and also during the operation and maintenance phase. Cesspit emptying contractors would be negatively affected as more households connect to the main sewers and therefore would be a decreased demand for their services

5.10 Infrastructure

To minimize the construction - related impact, works should be executed as quickly as possible and in accordance with safety and construction regulations. As a general recommendation, installations should be located as close to towns and villages as possible, reducing trenches' lengths and negative impacts on agriculture, and natural, cultural and economic resources. Minimum distances to inhabited areas would be maintained where possible to minimize noise and odour i.e. looking for a balance / optimum point between general and local needs.

As in the preceding points, new infrastructures would lead to facilities for other uses, giving a very positive general balance .In contrast, digging, trenching and other works can affect both cultural and natural heritage and agricultural production, etc. Construction works would make the most significant short – term negative impact but will be compensated for by a long – term global positive impact.

5.11 Effluent Reuse

Having considered the high percentage (about 70%) of water consumption for irrigation in comparison with the total consumption in most of the ESCWA countries, it is evident that water reuse for agricultural purposes is a recommended option for WWTP effluents. However, regulations in many countries forbid strictly the consumption of products irrigated with any treated wastewater, regardless of its quality. Therefore, this

reduces market opportunities .It seems foreseeable that restriction would increase within international markets. Another option to be considered is the reuse of wastewater in industry .It requires similar standards of quality but it would maintain a relatively constant level of needs in accordance with effluent production and probably would make a contribution to local economic and social development .In the case of industries, it would also generate a new effluent stream that could either be reused within the industry or discharged into sewers. Sanitary problems can be minimized using treated waters to irrigate cultivation of industrial application. If the water effluent has acceptable chemical, biological and microbiological levels, it must be suitable for unrestricted agriculture, unless fresh consumption is a preventive measure. Fruit cultivation must have less water quality requirements than vegetables, establishing security laps between last irrigation and crop collection such as forphyto – sanitary applications .It could be even more acceptable to allocate reuse of effluents to cultivation of products destined for food canning if they have any heating treatment such as tomatoes and jams .The ornamental sub – sector, mainly cutting flowers, is experiencing a rapid development internationally and there is no problem in irrigating ornamental plants with treated wastewater .
Given that water scarcity is one of the most serious problems in the ESCWA region, and a great increase in water demand is projected, every solution to increase water availability without overexploiting present resources would be a significant positive impact on the short or long - term.

5.12 Sludge Disposal or Reuse

Although treatment processes work as projected and sludge would completely be mineralized, avoiding pollution and odor impacts, sludge disposal will be very expensive and will require quite large areas. Having into account the large volumes of sludge and on the basis of previous experience, several uses are feasible, such as (i) to rehabilitate quarrying sites, landscaping and restoration of marginal areas, and (ii) to correct soil characteristics in agriculture and forestry .If it would be used to cultivate edible products we should be aware of the composition of sludge. It is more acceptable to use them for industrial purposes, because of the possibility of contents of harmful elements such as heavy metals. To avoid problems related to parasites and pathogens, the best alternative is to make compost with the sludge. When large volumes of wastewater are treated high sludge amounts would be produced from sewer – connected population. This will give a considerable environmental problem on land use and economy. The impact would be significantly negative on the long term .The reuse of sludge must reorientate a foreseeable problem to a new income source. Dried or dewatered treatment plant sludges are not considered as highly hazardous materials, nevertheless basic safe working procedures should be adopted to protect those working with sludge disposal such as: (i) appropriate vaccination to be given particularly hepatitis B, (ii) appropriate safety equipment to be used when working with the sludge for disposal – boots, gloves, overalls and facemasks, and (iii) basic hygiene procedure should be followed. Food and drinks should not be consumed in sludge areas and hands should be thoroughly washed after sludge handling operations before consuming food or drink.

5.13 Selection of Location For Effluent Reuse

Selecting a location for reuse of effluent near its production area has important advantages, such as (i) would allow maintaining water distribution throughout the country, contributing to economic distribution and diminishing concentration of pollution, (ii) would reduce significantly environmental costs by reducing trenching lengths, conveyance works, etc., and (iii) would reduce economic costs. But, such a location also needs the following requirements: (i) some investment to start the operation of the irrigation infrastructure, (ii) either soils of enough quality or with a technically and economically viable possibility of recovering in order to make the investment profitable, (iii) an organization to distribute and market its products, and (iv) some qualified human resources with sufficient technical level.
Selecting far distant location where the above mentioned requirements are available is also considered as an alternative to the nearby location when these requirements are not available .In both cases, however, the environmental impact would be significantly positive from the social point of view, and more in the first case whenever the requirements are available.

5.14 Historic, Archeological And Other Cultural Resources

Damage can be caused not just due to foundation and trenching works, but also for associated activities such as quarrying, borrow pitting, camping, temporary vehicle parks and so on .The risk of threat caused by trenching for conveyance network will be increased according to the length. So, as the most feasible solution concerning this point, it would be better to design WWTP's as close to villages and towns as possible. The detailed engineering design for a project of every new installation will safe guard that the finally selected emplacement dose not destroy any catalogued archeological remains. The Ministry of Tourism and Antiquities

of a country should provide a comprehensive database of the known archeological sites in that country. Considering the total amount of trenches that will be necessary to open, we must pay a special attention to the work in progress. In advance of pipe laying operation, there will be a need to prospect the line carefully in a band of 20 m wide .In areas not previously known for its remains, a visual prospecting will be enough, searching for any evidence. If an archeological remain is found, it will be a priority to stop trenching and wait for technical advice. Confidentiality will be essential in order to avoid the collection of pieces or even digging. This risk will persist provided that people could get any results. A second possible long –term impact could be the effect on monuments. It will affect its visual quality and its touristic attraction. The odor and the noise could increase this problem. This must be avoided by selecting locations for installations far away from monuments. Tree-barriers hiding the new WWTP could also aesthetically help in minimizing this impact.
The construction phase, including labours for excavation, digging or trenching will be the most dangerous. Moreover, movements of heavy machinery could damage some kind of remains even if they rest on relatively deep layers .In the positive side, the possibility of discovering any remain of cultural legacy would be a contribution to the country's development. Globally, there could be a significant negative irreversible impact, if archeological sites were found and the proposed measures were not applied carefully.

6. Mitigation of Negative Environmental Impacts

During the Preliminary Engineering Design Stage general guidelines for the mitigation of negative environmental impacts should be considered as individual scheme proposals are developed .The EIA should be updated for each scheme as it proceeds through the Detailed Design Stage. During construction, the contractors should be made aware of the general needs and methods of reducing environmental impacts as well as any scheme specific requirements. Following the construction of proposed schemes, the operation and maintenance of the schemes will be the responsibility of the concerned agency. This agency should ensure that adequate staff are recruited and trained in advance of scheme completion so that an adequate supply of experienced trained staff are available to correctly operate and maintain the treatment plants and the pipelines networks. Monitoring plan for all activities related to construction, operation and maintenance of each scheme should be prepared and carried out to ensure compliance with the required standards.

7. Environmental Standards And Legislation

The prohibition of the disposal of municipal and industrial wastewater into the courses of rivers and wadis before they are treated to standards allowing their unrestricted agricultural use dictates adoption of effluent standards to meet this criterion. At present, the adopted standards are normally selected after consultation of a number of authoritative national and international standards and other concerned organizations such as:

a. National Standards

The environmental standards at the national level (if they exist) normally include the following:
...Standards For Treated Domestic Wastewater (hydraulic and process)
...General Technical Specifications for Sewerage Works and for Water Supply Works.
...Design Bases and Design Criteria for Water Supply Works and for Wastewater Works.
...Standards for Odor, Toxicity, Noise and Dust.
...Guidelines For Selection of Location of WWTP
...Guidelines For Selection of Location For Effluent Reuse.
...Guidelines For Mitigation of Negative Environmental Impacts
...Ministry of Health Guidelines for Domestic Water Supply And For Wastewater Reuse.
...Reclaimed Water Standards for Irrigation.
...Guidelines for the Reuse of Treated Wastewater in Irrigating Vegetables, Fruit Trees, Industrial Crops and Cereals.
...Standard Guidelines For Drinking Water
..."Guidelines For Connecting Industrial Wastewater to the Public Sewage Network".
...Standards For Industrial Wastewater – Maximum Allowable Limits (mg/L) For Effluent to Stream orWater Impounding, Natural Groundwater Recharge And Water Reuse For Irrigation".

b. Relevant National Environmental Legislation

The National Legislation For the Environment (Laws and Bylaws) should include the following:
...Protection of the Environment Law.
...Wastewater and Sewerage Law.

...Water and Wastewater Institution Law (Authority, Ministry, Department, etc.).
...Regulations of Towns, Villages and Buildings Law
...Public Health Law.
...Agriculture And Use of Agrochemicals Law (fauna, flora, uses of sludge, Uses of Fertilizers, Pesticides and Insecticides, Desertification).
...Prevention of Nuisance and Collection of Solid Waste Law.
...Development and Regulation of Natural Resources Law.
...Mining Law.
...Punishment Law.
...State Land Administration Law (Including Lease and Rent).
...Housing and Human Settlements Law.
...Protection of Archaeological and Historical Sites Law.
...Air Quality Law (Traffic, Public Health, etc.).
...Noise Law (Municipalities, Public Markets, Traffic, etc.)
...Marine Life Law (including Ships Law).
...Habitat And Wildlife Law.
...Sludge disposal And / Or Reuse Law.

c. International Effluent Standards

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3. "FAO Guidelines For Interpretation of Water Quality Data", 1988.
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Summary

Development, updating and formulation of specifications, norms, standards, codes, guidelines, rules, regulations, policy measures and Legislation at the national level to be applied in the planning, investigation, design, construction, utilization, monitoring and evaluation, and environment protection for wastewater development, management and reuse are essential to all ESCWA member states. Deficiencies and strengths of wastewater standards have to be pointed out. Trends in updating current standards, impacts of harmonizing these standards including framework and procedures for realizing harmonization, and the potential for their unification at the national, sub – regional and regional levels cannot be overemphasized. Technical, administrative and legal capacity of concerned authorities in the implementation and enforcement of these standards have to be assessed and remediation measures effected.

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Table (2)

ALTERNATIVES FOR STORAGE OF THE POSSIBLE WASTEWATER SURPLUS DURING NON – IRRIGATION PERIODS

FACTORS	STORAGE IN DAMS	STORAGE IN TANKS	INJECTION TO AQUIFERS	DISCHARGE TO WADIS
Biological Benefits As A Consequence of Presence of Water In Wadis	significant	null	**null**	**very significant**
Risk of Pollution of Aquifers	moderate	null	**very significant**	low
Energy Requirement To Recover The Stored Water	**low**	null	significant	**low**
Possibility of General Environmental Damage	**very significant**	very low	moderate	**low**
Economic Investment	**very significant**	significant	low	**null**
Risk of Losses By Evaporation	**very significant**	null	null	**very significant**
Risk of Eutrophication	**very significant**	null	null	**very significant**
Geological And Topographical Dependence	**very significant**	null	moderate	very low
Risk of Unavailability of Treated Wastewater	**low**	null	low	**very significant**
Risk of Loss of Permeability	not significant	null	moderate	**very significant**

Table (3)

OPTIONS FOR SELECTING LOCATIONS WHERE TREATED WASTEWATER COULD BE REUSED

FACTORS	CLOSE TO EFFLUENT PRODUCTION	IN THE JORDAN VALLEY
Contributes To Productivity Distribution	yes	no
Avoids Concentration of Population	yes	no
Need For Economic Investment In Construction	**lower**	higher
Investment To Start The Operation	**yes**	already exists
Availability of Good Soil Quality	**variable**	yes
Possible Damages To Biological Resources	**less significant**	very significant
Pre -existence of Commercial Network	**often not existing**	yes
Presence of Qualified Human Resources	**often not existing**	yes

Table (4)

ENVIRONMENTAL MITIGATION MEASURES

WORK ITEM	POTENTIAL IMPACT	MITIGATION MEASURE/S TO BE APPLIED WHERE POSSIBLE
1. Pipelines	High energy usage and costs	Design pipelines to operate with gravity flow.
	Disruption of natural environment	Align pipelines along existing roads to minimize additional disturbance of the natural environment. Pipeline routes to avoid sites of special biological importance.
	Damage to antiquities / tourist area	Pipeline routes to avoid known archaeological sites.
2. Treatment Plant Process	High energy usage and cost	Low energy solutions will be adopted where possible, pumping within the treatment plant site to be minimized using natural ground contours.
	Odor	Treatment processes to be correctly designed to ensure low odor levels. Extremely long - delivery pipelines to treatment plants to be avoided to prevent delivery of septic sewage to treatment plants. Where necessary odor control units will be considered, although it is preferred not to use these due to additional capital and O&M works, and additional energy and chemical usage. Process correctly designed to ensure a stable sludge is produced.
	Sludge Odor	Provide a green screen of trees and bushes around treatment plant sites to minimize dispersion of offensive odors.

Table (4) continue

ENVIRONMENTAL MITIGATION MEASURES

WORK ITEM	POTENTIAL IMPACT	MITIGATION MEASURE/S TO BE WHERE POSSIBLE
3.Treatment Plant Location	High energy use and cost	Position treatment plants at lowest level in served areas so that pumped flows to the plant are either not required or minimized.
		Select gently sloping sites so that flow to and from the treatment plant may be discharged by gravity through the works.
	Odor	Locate treatment plants away from centers of pollution. {Note however that as distance to the treatment plant increases there are additional impacts from pipeline construction}.
	Visual Intrusion	Provide screening trees around and within treatment plants. Consider planting trees at remote locations to prevent treatment plant being viewed
	Loss of land use	Select treatment plant sites on unused non-productive land or low-grade agriculture land.
		Where suitable land of low intensity use is not available consider alternative treatment processes to minimize land loss.
		Consider use of mechanical dewatering rather than sludge drying beds
		Use slow sand filters rather than maturation ponds.
4. Treatment Plant Equipment	Noise	Select low noise operations where possible. Specify low allowable machinery noise when sourcing equipment
5. Reuse Storage Facilities	**Loss of land use**	Utilize existing storage facilities to minimize additional land loss

Appendix

CASE STUDY- JORDAN

WASTEWATER – TREATEMENT, STANDARDS, STORAGE, LOCATION FOR REUSE AND ENVIRONMENTAL MITIGATION MEASURES –

1.Introduction

Many benefits such as raising the sanitation levels, improving public health and pollution control of surface water and groundwater are realized when wastewater collection and treatment systems are implemented . The implementation of wastewater collection, treatment, disposal and/or reuse projects will have significant overall positive impacts on the environment by: (i) preventing the discharge of contaminating wastewaters to the Yarmouk River and Jordan River, (ii) preventing the disposal of untreated municipal sewage within the served areas, (iii) improving surface water and groundwater quality, and (iv) making treated wastewater available for use in agriculture or industry thereby reducing pressure on Jordan's remaining scarce water resources

Wastewater flow generation equal to 80% of the water supplied to consumers has been taken for Jordan with a net wastewater generation figure of 130 L/c/d being adopted for communities with populations of 100,000. or larger with successively lower figures being adopted for smaller populations i.e. 130 L/c/d for population over 100,000.120 L/c/d for population between 25,000. – 100,000. ,115 L/c/d for population between 10,000. – 25,000., 100L/c/d for population between 2,000. – 10,000., and 90 L/c/d for population less than 2,000 people.

One major problem facing most of the existing WWTP's in Jordan is receiving domestic wastewater with high strength in terms of BOD_5 (500 – 1500 mg/l). This is attributed to the low water consumption. Water shortage also imposes several operational problems and some existing plants are being biologically over loaded with only a portion of their hydraulic capacity. Other WWTP's are hydraulically over loaded due to increase in amounts of effluent discharged to the plants..

1. Standards And Treatment Processes

The prohibition of the disposal of municipal and industrial wastewater into the courses of rivers and wadis before they are treated to standards allowing their unrestricted agricultural use dictates adoption of effluent standards to meet this criterion. At present, standards in Jordan are normally selected after consultation of a number of authoritative national and international standards and other concerned organizations. The adopted standards in Jordan for wastewater reuse in unrestricted agriculture following secondary treatment and tertiary treatment of wastewater as shown in **(Table 1)** are based on wastewater effluent strength of Biochemical Oxygen Demand (BOD_5 =70 g / c / d), total Suspend Solids loading (SS= 70 g / c / d)and Total Kjeldhal Nitrogen (Nitrogen N – TKN =12g/c/d):

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Table 1
Jordan Standards For Wastewater Treatment

Following Secondary Treatment		Following Tertiary Treatment	
BOD_5	30mg/L	BOD_5	30mg/L Expected level 10mg/L
TSS	30mg/L	TSS	30mg/L Expected level 10mg/L
NH_4	15mg/L	Coliform Count	MPN/100ml <1000
		Nematode Eggs	<1/Litre
		Giardia Cysts	<1/Litre

To minimize the health risk associated with the use of treated wastewater; the Ministry of Health in Jordan drew up certain regulations to control this practice. According to these regulations raw or partially treated wastewater is prohibited for any use. Jordan adopted the recent WHO guidelines which require a microbiological quality of faecal coliforms less than one 1000 MPN/100 ml and intestinal nematode eggs count of less than one per litre of treated wastewater to be used for unrestricted irrigation. Also, the Jordanian regulations do not allow the use of treated wastewater for irrigating raw–eaten crops. From the viewpoint of the chemical quality of treated wastewater, FAO guidelines are usually followed to assess the presence of toxic chemicals, which may influence the agricultural products. Major problems in this respect are the relatively high concentrations of TDS, Cl and Boron (B) in the treated effluent, which need to be always monitored and analyzed. The adverse impacts of these elements could be minimized by improving the management side of dealing with low – quality water by controlling the irrigation method, crop type and soil management. Regarding industries in Jordan, there are regulations which define the maximum allowable concentrations of pollutants in effluent discharged from their own treatment plants .In addition, regulations were set up to control discharge of industrial effluent into the public sewer systems. The existing standards (local and international) and the guidelines of the WHO and FAO suggest treatment processes to meet health criteria uses of reclaimed wastewater

The Standards followed in Jordan are proposed for the irrigation of crops likely to be eaten uncooked (and for sports fields and public parks) published by the WHO Scientific Group in Technical Report No.778 of 1989 and in particular the "Recommended Microbiological Quality Guidelines for Wastewater Effluent Use in Agriculture" . These standards are stringent requirements and will demand the provision of sand filtration in the tertiary stage of the domestic and industrial wastewater treatment to ensure that the nematode eggs and Giardia Cyst standards are met.

The design philosophy and approach normally adopted in network planning for wastewater collection in Jordan are generally in accordance with the national standards and practice .Each community is considered for its suitability in being provided with wastewater collection and treatment facilities. In particular, consideration is given to how adjacent communities can be linked together by trunk sewers so that the wastewater from a number of communities can be treated at a single wastewater treatment plant. Concrete sewers are proposed in most areas with ductile iron pipelines being used for pumping mains or where additional structural strength is required .In areas where aggressive soil conditions are expected, UPVC pipes are proposed for small pipelines with GRP adopted for larger pipelines .The minimum pipe sizes recommended for sewers and house connections are 200 mm and 150 mm respectively.

For wastewater secondary treatment, five generic process types of main biological treatment processes are normally proposed, these are: (i) waste stabilization ponds, (ii) trickling filters, (iii) Rotating Biological Contactors (RBC's), (iv) extended aeration, and (v) conventional activated sludge. Tow alternative tertiary treatment processes are adopted for use in relevant situations, these are: (i) maturation ponds and (ii) slow sand filters.

Process streams are developed for each of these processes with an appropriate head works included for preliminary treatment in each case and effluent disinfection using chlorine in all process streams. Where primary clarification is a necessary part of the treatment process, continuously scraped sedimentation tanks

are included on large plants with either Imhoff tanks or anaerobic lagoons being adopted for smaller communities .The treatment proposals usually include for the provision of septage (septic tank emptying liquors) at all treatment plants with design populations exceeding 30000 people. Sludge removal from Waste Stabilization Ponds (WSP's) is typically only necessary about once every five years and therefore WSP plants and where anaerobic ponds are provided then sludge drying beds are not included.

3. Wastewater Development Options And Prioritization of Treatment Facilities

Wastewater collection and treatment and disposal options are identified and evaluated for the separate communities in Jordan and in turn grouped into sub-projects except the very small communities (less than 2500 people) that are generally located too far from adjacent communities and with inhospitable intervening topography which make their linkage to other communities not viable for wastewater treatment. Hence, it is usually proposed that these communities will either be served by treatment plants serving solely their own communities or in many cases due to their small size and the physical difficulties of providing a treatment plant, septic tanks or similar property based disposal methods are normally judged suitable for the foreseeable future .A two – stage prioritization process is usually adopted, initially, a "first - stage" analysis for ranking the polluting potential of each community against selected criteria, and aggregating the scores for each community often applying weighting to the tow key pollution determinants, namely: community population and distance from areas to be protected environmentally and socioeconomically .The "second - stage" of prioritization is grouping of communities into sub – projects which are prioritized for their combined polluting potential .In this second stage each identified subproject is screened and ranked against the following criteria :

...Total population served
...Location of population nodes with respect to each other
...Distance from areas to be protected environmentally and socioeconomically .
...Potential for practical effluent reuse options
...Risk to pollution of surface water (rivers and wadis) and groundwater aquifers

Again aggregate scores are calculated for each of the subprojects and those with highest scores representing the highest priorities .The ranking sequence does not indicate the absolute priority for construction, rather that all schemes should be implemented as soon as funds are made available. Economic and financial analyses are undertaken to assess the relative merits of linking small communities together with either gravity sewers and/or pumping mains as opposed to providing separate treatment plants for individual communities. Thus, analyses for Jordan showed that even for population centers as small as 2500 people, separated by up to 3 km distance, the Net Present Cost (NPC) of linking them via pumped or gravity mains was only marginally more expensive than the NPC's calculated providing separate treatment plant at each. Hence, it was concluded that it was preferable to link communities of this size rather than having a proliferation of small treatment plants with the associated attendance / maintenance problems.

Similar analyses were undertaken to evaluate the cost effectiveness of different treatment processes for populations of various sizes. These analyses were carried out taking into account recurrent operation and maintenance costs as well as capital construction costs .The NPC's from these analyses demonstrated that for smaller populations, RBC's and trickling filters provided the most cost effective investment whereas for populations greater than 25000 people extended aeration and conventional activated sludge provided the best investment options. For populations of above 150000 people conventional activated sludge becomes the clear winner. Waste Stabilization Ponds (WSP's) consistently performed well with low NPC's but space considerations ruled out such plants in almost all cases.

Economy is one of the basic criteria for the engineering design of a project. The Economic International Rates of Return (EIRR's) of the priority projects in Jordan were calculated for new schemes and varied between +4% and - 4 % for both the "With" and "Without" tertiary treatment options. The Financial Internal Rates of Return (FIRR's) are consistently negative in the range of –2.0 % to -6.0% for the new schemes. These show for a conventional analysis that all the new priority projects have FIRR's below the discount rate, and hence are not viable. However, in all cases, the revenues obtained exceed the operations and

maintenance costs for each year, so they are viable as long as the capital costs are not taken into account. Extensions to existing plants generally showed positive rates of return as the costs of the existing facilities have not been incorporated in the analysis.

To minimize capital and operation costs, the treated effluent is used in existing systems where available and not transported over long distances. If it is possible to utilize the treated effluent stream in existing irrigation systems this will require the minimum additional capital cost .The treated effluent may be used either to replace or supplement the existing source of irrigation water. If it is not possible to utilize an existing irrigation system then a separate dedicated irrigation system may be provided. Wherever possible, the effluent should be re-used as close to the treatment plant as possible to minimize capital and operation and maintenance costs of the conveyance system .If practical reuse option is not available then the treated effluent will be discharged to wadis or rivers thus supplementing current surface water or groundwater.

Where reuse is practiced, the sale of treated effluent for irrigation with either partial or full recovery of the marginal cost for additional treatment, storage and conveyance is an option, subject to the willingness of consumers to pay for the water. However, it is likely that the true marginal cost will need to be heavily subsidized, at least until the practice of using treated effluent is accepted and the cost of water from other sources rises to comparable unit price.

4. Treated Wastewater Storage

Water availability and water consumption in Jordan are not regular throughout the year. Rainfall and air humidity are higher in the cold period /winter season, but the demand for water supply is lower in this period. In contrast, the water demand for agricultural purposes is highest during hot periods. It is assumed that all of the treated wastewater produced during hot periods can be re – used either for industrial or agricultural purposes either close to or remote from the treatment plants with the provision of suitable distribution pipework. Excess treated wastewater produced during cold periods, which is not required for agricultural use may be discharged to wadis and thus will not be available for re – use. To enable this water to be reused storage reservoirs could be a feasible option. Alternatives to storage of the possible wastewater surplus in cold times are to: (i) store the probable wintertime surplus of treated wastewater in existing dams, (ii) keep treated wastewater in closed deposits, (iii) store the surplus of treated wastewater in aquifers by any injection system, and (iv) discharge the treated wastewater to wadis allowing natural drainage **(see table 2).**

5. Selection of Location For Effluent Reuse

Selecting a location for reuse of effluent near its production area has important advantages, such as: (i) would allow maintaining water distribution throughout the country, contributing to economic distribution and diminishing concentration of pollution, (ii) would reduce significantly environmental costs by reducing trenching lengths, conveyance works, etc., and (iii) would reduce economic costs. But, such a location also needs the following requirements: (i) some investment to start the operation of the irrigation infrastructure, (ii) either soils of enough quality or with a technically and economically viable possibility of recovering in order to make the investment profitable, (iii) an organization to distribute and market its products, and (iv) some qualified human resources with sufficient technical level.

Selecting a far distant location where the above mentioned requirements are available is also considered as an alternative to the nearby location when these requirements are not available .In both cases, however, the environmental impact would be significantly positive from the social point of view, and more in the first case whenever the requirements are available.Options for selecting the locations where treated wastewater could be re – used in Jordan are shown in **Table 3**.

6. Mitigation of Negative Environmental Impacts

The EIA carried out in Jordan for wastewater collection, treatment, disposal and/or reuse systems project for the catchment area of the Yarmouk River and Jordan River, in the Preliminary Design Stage, addressed in broad terms the significant environmental issues to be considered. However it is emphasized that further EIA

activities will be implemented during the Detailed Engineering Design Stage considering individual schemes and sites selected.The general principles to be followed is that positive impacts should be enhanced wherever possible while potential negative impacts should be eradicated, or minimized and with suitable mitigation measures taken wherever possible

During the Preliminary Engineering Design Stage general guidelines for the mitigation of negative environmental impacts should be considered as individual scheme proposals are developed .The EIA should be updated for each scheme as it proceeds through the Detailed Engineering Design Stage. During construction, the contractors should be made aware of the general needs and methods of reducing environmental impacts as well as any scheme specific requirements. Following the construction of proposed schemes, the operation and maintenance of the schemes will be the responsibility of the concerned agency. This agency should ensure that adequate staff are recruited and trained in advance of scheme completion so that an adequate supply of experienced trained staff are available to correctly operate and maintain the treatment plants and the pipelines networks. Monitoring plan for all activities related to construction, operation and maintenance of each scheme should be prepared and carried out to ensure compliance with the required standards. General guidelines for the mitigation of negative environmental impacts are detailed in **Table 4.**

Summary

Standards for wastewater collection, treatment, disposal and/or reuse in Jordan have evolved by taking into consideration the proposed treatment processes and national and international environmental standards and guidelines. Wastewater development options and prioritization of treatment facilities, proposals for treated wastewater storage, selection of locations for reuse of treated effluent and mitigation of environmental impacts have been assessed for Jordan awaiting financing of projects for implementation.

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