Water treatment and water quality

Workshop on Environment statistics

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Prepared by
Khamis Raddad
Amman – Jordan

Water treatment and water quality

The water treatment is a process to reduce pollutant in the water. It could be applied for fresh water to purify it to become suitable for human use, or could be applied for sewage and used water to treat it before disposed into the sea or reuse it for irrigation purpose.

The treatment could by done by mechanical, biological and advanced treatment.

Waste water generation

The waste water is a liquid waste generated from different sources like households, economic enterprises and agriculture. It disposed in different ways with or without treatment, in some cases this type of waste water reused in agriculture and forest activity.

The pollutant in waste water is varied depending on the source of waste water, as example the household waste water contains organic pollutant, but the manufacturing waste water contains heavy metals.

(It is quite difficult to differentiate in a precise manner between the various pollution sources contributing to the total waste water *load* of a stream. When a sewerage system is present, industrial wastes are released, combined with human wastes and the wastes from storm run-off. Human wastes may be assessed on the basis of standard emission factors (e.g. PE = person equivalents), just like small businesses. Big enterprises may be assessed individually, based on computations and monitoring at the source. The balance of the total load then can be attributed to other sources, mainly diffuse ones. This kind of computations becomes indispensable when levies are raised to cover the costs for the sewerage system and waste water treatment plants) source tromp.

The waste water is classified by source depending on economic activity (ISIC classification is required) as it is mentioned in the questionnaire table no. W 4 :

Total waste water generated

The total quantity of water in cubic meters (m^3) that is discharged due to being of no further immediate value to the purpose for which it was used or in the pursuit of which it was produced because of its quality, quantity or time of occurrence. It classified into main items as followed:

- agriculture, forestry and fishing (ISIC 01-05)

this activity produce drainage water that contains a lot of salt and other pollutant comes mainly from fertilizers and manure used and pesticides applied to increase the production and treat the crops.

The importance of this activity is due to the huge quantity of water used and the dangers of toxic materials used in it, and side effect of drainage water in increasing the salinity of soil and cause desertification if does not treated in the proper way.

the reduction of pollutants and treat the swage water is essential.

- Mining and quarrying (ISIC 10-14)

This activity use a lot of water for leaching the minerals and in purification of minerals produced and other process in mining and quarrying.

The waste water generated from this activity contains salts and heavy metals (depending on the mining activity and type of process applied).

- Manufacturing Industries (ISIC 15-37)

Due to a wide variety of activities classified under this category, (it includes as example food industry, medicine industry, pesticides, fertilizes, detergents, and plastic and rubber), a wide range of raw materials are being processed into various industrial, so this industries discharge a broad array of wastewater. Chemical, and metal, and detergent materials may discharge primarily toxic substances and compounds, such as metals, acids and cyanides into water body and in nature.

- Production and distribution of electricity (ISIC 40)

The production of electricity needs water to cooling of generators, the quantity of water consumed and concentration of pollutant matter in the water depends on the type of generator and fuel used.

In general this activity may produce hot water with some heavy metals and other pollutant.

- Construction (ISIC 45)

The quantity of water used and waste water generated from this activity varied from country to country due to the row material used in construction and the size of construction in the country.

The ratio between waste water generated and water used is small, and the waste water may be contains some salt and calcium and some soil particulars.

- Other economic activities

It includes services activity like hotels, restaurants, health care services, entertainment activity, education, and trade activity.

Some of these activities like health care activity ,laboratory and education activities produce hazardous waste and part of it disposed with sewage water without any treatment.

- Households

The households generate waste water contains organic matter, and some chemical materials due to use of detergent in cleaning and washing in the house. The households is considered as the second consumer of water after the agriculture activity, and the many houses use cesspool to disposed the waste water, some time they use unlined cesspool, so the waste water pollute the ground water.

As mentioned above it is a difficult job to get reliable data about quantity of waste water for a series from 1990 by source. A conducted of a survey is required to provide some data, and you can obtained others by official records. So this questionnaire required more accurate data to be filled in.

Table w4a: waste water generation

Priority	Category	Unit	1990*	1995*	1996	1997	1998	1999	2000	2001	2002
!	**Total waste water generated**	1000 m^3/d									
	by: Agriculture, forestry and fishing (ISIC 01-05)	1000 m^3/d									
	Mining and quarrying (ISIC 10-14)	1000 m^3/d									
	Manufacturing Industries (ISIC 15-37)	1000 m^3/d									
	Production and distribution of electricity (ISIC 40)	1000 m^3/d									
	Construction (ISIC 45)	1000 m^3/d									
	Other economic activities	1000 m^3/d									
	Households	1000 m^3/d									

Waste water treatment

Increasing urban populations and production growth boost volumes of wastewater. In large parts of the world, substantial amounts of the discharges of domestic sewage and industrial effluents are still untreated. And in urban areas with sewage treatment plants, treatment capacities are often far exceeded by the rapid pace of urban growth and development (ESCAP, 1992).

Wastewater treatment plants act as the natural self-purification of water. The quality of treated wastewater is largely depend on the type of treatment technology used. In primary (mechanical) treatment, only settle able materials are separated from wastewater, and the remainder is released again without further treatment. In secondary (biological) treatment, organic material is mineralized through the action of bacteria; the net result is that BOD is decreased. In advanced treatment, selected minerals like phosphorus are removed by binding them into insoluble substances and this treatment is more expensive than other methods.

The main function of a wastewater treatment plant is to remove biodegradable matter. Thus, an important variable to record is the quantity of BOD in the influent entering the plant and the quantity released by the plant in the treated effluent. The difference constitutes an important measure of the treatment efficiency. Whereas a properly functioning biological treatment plant may remove as much as 90% of BOD, a primary treatment plant may remove only about 30%.

Total waste water treatment

Process to render waste water fit to meet applicable environmental standards or other quality norms for recycling or reuse. Three broad types of treatment are distinguished in the questionnaire: mechanical, biological and advanced. For the purpose of calculating the total amount of treated waste water, volumes reported should be shown only under the highest type of treatment to which it was subjected. Thus, waste water treated mechanically as well as biologically should be shown under biological treatment, and waste water treated in accordance with all three types should be reported under advanced treatment. Waste water treatment does not include the collection of waste water or storm water, even when no treatment will be possible without collection.

The questionnaire required information for the quantity of swage water treated for a series from 1990. the data required supposed to be available because the main source of this data is official records.

Types of wastewater treatment processes

1- **Mechanical treatment**

Processes of a physical and mechanical nature which result in decanted effluents and separate sludge. Mechanical processes are also used in combination and/or in conjunction with biological and advanced unit operations.

In this operation a coarse materials like plastics and wood are separated by lowering the water flow speed in large basins, sand and fine inorganic and organic particles will settle, and periodically removed as sludge. Floating compounds like oils are skimmed of the surface of water.

Mechanical treatment is understood to include at least such processes as sedimentation, flotation, etc. To avoid double counting, water subjected to more than one treatment should be reported under the highest level of treatment only.

2- Biological treatment

Processes which employ aerobic or anaerobic micro-organisms and result in decanted effluents and separated sludge containing microbial mass together with pollutants.

the anaerobic and aerobic microorganism oxidize the organic matter, as a result of this process the fine minerals sludge will settle and the remaining fluid is discharged into a surface water body or alternatively reused.

Biological treatment processes are also used in combination and/or in conjunction with mechanical and advanced unit operations. To avoid double counting, water subjected to more than one type of treatment should be reported under the highest level of treatment only.

3- Advanced treatment

Process capable of reducing specific constituents in waste water not normally achieved by other treatment options like N and P and pathogens and worm eggs.

For the purpose of this questionnaire, advanced treatment technology covers all unit operations which are not considered to be mechanical or biological. In waste water treatment this includes e.g. chemical coagulation, flocculation and precipitation, break-point chlorination, stripping, mixed media filtration, micro-screening, selective ion exchange, activated carbon adsorption, reverse osmosis, ultra-filtration, electro-flotation. Advanced treatment processes are also used in combination and/or in conjunction with mechanical and biological unit operations. To avoid double counting, water subjected to more than one treatment should be reported under the highest level of treatment only.

Table no. W 4b in the questionnaire includes the items below:

1- Waste water treated in public treatment plants

All treatment of waste water in municipal treatment plants by official authorities, or by private companies for local authorities, whose main purpose is waste water treatment.

This item divided into three sub items by method of treatment:

- Mechanical treatment
- Biological treatment
- Advanced treatment

2- Waste water treated in other treatment plants

Treatment of waste water in any non-public treatment plants, i.e. industrial waste water plants. Excluded from 'Other waste water treatment' is treatment in facilities covered under independent treatment facilities such as septic tanks.

3- Waste water treated in independent treatment facilities

Individual private treatment facilities to treat domestic and other waste water in cases where a public waste water network is not available or not justified either because it would produce no environmental benefit or it would involve excessive cost. Examples of such systems are treatment in septic tanks.

4- Non treated waste water

Waste water discharged into ambient media without treatment.

5- Total sewage sludge production

The accumulated settled solids, either moist or mixed, with a liquid component as a result of natural or artificial processes, that have been separated from various types of waste water during treatment (Please provide the data as dry weight. If data is only available for wet weight, please fill in the data for wet weight and specify this in a footnote).

Table W4B: waste water treatment

Priority	Category	Unit	1990*	1995*	1996	1997	1998	1999	2000	2001	2002
!	**Waste water treated in public treatment plants**	1000 m^3/d									
	of which: Mechanical treatment	1000 m^3/d									
	Biological treatment	1000 m^3/d									
	Advanced treatment	1000 m^3/d									
!	**Waste water treated in other treatment plants**	1000 m^3/d									
	Waste water treated in independent treatment facilities	1000 m^3/d									
!	Non-treated waste water	1000 m^3/d									
	Total sewage sludge production	1000 t									

Waste water treatment facilities

Table 4c in the questionnaire includes this items

Population connected to waste water collecting system

The percentage of the resident population connected to the public waste water collecting systems (sewerage). Public waste water collecting systems may deliver waste water to treatment plants or may discharge it without treatment to the environment.

Population connected to waste water treatment

The percentage of the resident population whose waste water is treated at public waste water treatment plants.

Population connected to independent treatment (septic tanks)

The percentage of resident population whose waste water is treated in individual, often private facilities such as septic tanks.

Waste water treatment plants: as mentioned in the waste water treatment it dived into three types as followed:

Mechanical treatment
Biological treatment
Advanced treatment

In this item the questionnaire required the number of treatment plant by the type.

Design capacity of waste water treatment plants : it is the maximum quantity of waste water could be treated in the treatment plant, it includes both hydraulic load (m^3/d) and organic load (mg/L) the questionnaire required only hydraulic load, the operated load of the plant could be more than the design capacity, so the water not treated well.

The design capacity data is required by type of treatment plant as follow:

Mechanical treatment
Biological treatment
Advanced treatment

Table W4C: Waste water treatment facilities

Priority	Category	Unit	1990*	1995*	1996	1997	1998	1999	2000	2001	2002
!	Population connected to waste water collecting system	%									
!	Population connected to waste water treatment	%									
!	Population connected to independent treatment (septic tanks)	%									
!	**Waste water treatment plants**	number									
	of which: Mechanical treatment	number									
	Biological treatment	number									
	Advanced treatment	number									
!	**Design capacity of waste water treatment plants**	1000 m^3/d									
	of which: Mechanical treatment	1000 m^3/d									
	Biological treatment	1000 m^3/d									
	Advanced treatment	1000 m^3/d									

Table W5: Selected Variables at the City level

Water bodies providing public water supply:

Water bodies to which waste water is discharged:

Priority	Category	Unit	1990*	1995*	1996	1997	1998	1999	2000	2001	2002
!	City Population	1000									
!	Population connected to waste water collecting system	%									
!	Population connected to waste water treatment	%									
!	Public water supply (ISIC 41):	mio m^3/y									
	of which to Households	mio m^3/y									

!	Waste water generated	1000 m^3/d									
!	**Treated in public treatment plants**	1000 m^3/d									
	of which: Mechanical treatment	1000 m^3/d									
	Biological treatment	1000 m^3/d									
	Advanced treatment	1000 m^3/d									
!	Treated in other treatment plants	1000 m^3/d									
!	**Waste water treatment plants**	number									
	of which: Mechanical treatment	number									
	Biological treatment	number									
	Advanced treatment	number									
!	**Total design capacity of waste water treatment plants**	1000 m^3/d									
	of which: Mechanical treatment	1000 m^3/d									
	Biological treatment	1000 m^3/d									
	Advanced treatment	1000 m^3/d									

Water quality*

The amount of conditions and substances affecting the quality of water is quite great. the main categories are presented and general remarks are :

- Physical conditions: such as suspended solids (which cause turbidity and prevent light penetration), sediments, conductivity, salinity and temperature;
- General chemical conditions: oxygen, pH, and related factors such as carbon dioxide, the presence of carbonates and bicarbonates, acidity and alkalinity;
- Pathogens: causative agents of water-borne diseases such as typhoid, paratyphoid, dysentery, and viral hepatitis. The presence of fecal coliform is often used as an indicator of the degree of sanitary quality of water bodies;
- Oxygen-consuming substances: consisting of organic compounds being degraded by micro-organisms using oxygen dissolved (DO) in the water;
- Nutrients: like phosphorus and nitrogen, which promote the growth of algae and aquatic plants;
- Toxic substances: like heavy metals or persistent pesticides, which are not readily biodegradable and accumulate in food chains;
- Radioactive substances: which may be accumulated in aquatic organisms that serve as food for human beings (with direct ingestion also via drinking water).

***** ***SOURCE: TROMP***

Parameters of water quality

Biochemical Oxygen Demand (BOD5)

Amount of dissolved oxygen required by organisms for the aerobic decomposition of organic matter present in water. This is measured at 20 degrees Celsius for a period of five days. The parameter yields information on the degree of water pollution with organic
matter.

This is usually defined as the amount of oxygen required by bacteria to oxidise biodegradable organic matter under aerobic conditions. BOD is one of the most important indicators of water pollution.
The obvious advantage of BOD is that it can reproduce oxygen consumption similar to that occurring in real water bodies as a natural process. Consequently, BOD is a good indicator for (a) rivers where shortage of DO is of prime importance and (b) for biological wastewater treatment. Also, BOD is easy to analyse, and entails low costs.

Dissolved Oxygen (DO)
Amount of gaseous oxygen (O_2) actually present in water expressed in terms of either of its presence in the volume of water (milligrams of O_2 per liter).

Chemical Oxygen Demand (COD)
COD is defined as the total quantity of oxygen required for the oxidation of organic pollutants into carbon dioxide and water. It is based upon the fact that all organic compounds, with a few exceptions, can be oxidised by the chemical action of strong oxidising agents under acid conditions.
Index of water pollution measuring the mass concentration of oxygen consumed by the chemical breakdown of organic and inorganic matter. This is a measure of potassium permanganate ($KMnO_4$) consumed, calculated in terms of oxygen equivalent.

Total Dissolved Solids (TDS)
Total weight of dissolved mineral constituents in water. Excessive amounts make water unsuitable for drinking or for use in industrial processes.

Total Phosphorus

Sum of phosphorus compounds in water measured in terms of phosphorus. Phosphorus is an element that, while being essential to life as a key limiting nutrient factor, nevertheless contributes - together with nitrogen - to the eutrophication of lakes and other bodies of water.

Total Nitrogen

Sum of inorganic and organic nitrogen compounds (excluding N_2) in water measured in terms of nitrogen. Nitrogen - together with phosphorus - contributes to eutrophication of water bodies.

Faecal Coliform

Microorganisms found in the intestinal tract of human beings and animals. Their presence in water indicates faecal pollution rendering water unsuitable for drinking without prior treatment.

Chlorophyll-a (Chl-a)
The photosynthetic green pigment present in most plants or algae. Chlorophyll-a is an indicator of the degree of eutrophication of water bodies.

Key water quality parameters for various water uses

Public water supply	Industrial water supply	Agricultural water supply	Aquatic life and wildlife maintenance	Recreation and aesthetics
Coliform bacteria Turbidity Colour Taste-odour Trace metals Dissolved solids Trace organics Chlorides Fluorides Sulphates Nitrates Cyanides Radioactivity	Processing (except foods) pH Turbidity Colour Hardness Alkalinity/acidity Dissolved solid Suspended solids Trade metals Trade organics Cooling pH Temperature Silica Aluminium Iron Manganese Hardness Alkalinity/acidity Sulphates Dissolved solids Suspended solids Sanitary (same as for public supply)	Farmstead: (same as for public supply) Livestock: (similar to that for public supply) Irrigation: Dissolved solids Specific conductance Sodium Calcium Magnesium Potassium Boron Chlorides Trace metals	Temperature DO pH Alkalinity/acidity Dissolved solids Salinity Carbon dioxide Turbidity Colour Settleable materials Floating material Tainting substances Toxic materials Nutrients Substances adversely affecting wildlife	Recreation Coliforms Turbidity Colour pH Odour Floating materials Settleable materials Nutrients Temperature Aesthetics Turbidity Colour Odour Floating materials Settleable materials Nutrients Temperature Substances adversely affecting wildlife

Water quality for aquatic life and wildlife*

In a balanced aquatic ecosystem, symbiosis exists among organisms. Heterotrophic bacteria in water consume organic matter and release carbon dioxide and simple nutrient elements. These are then taken up by autotrophic algae for growth and reproduction, thus freeing oxygen (beneficial to all aquatic animals) in the process. The build-up of organic matter by algae is called primary production.

When algae production reaches a level where carbon dioxide released by bacteria is not sufficient for their growth, an imbalance will occur. Under such circumstances, many algal species will obtain their carbon dioxide supply by splitting bicarbonate ions to release carbonate ions, thus increasing pH level. If pH reaches a value of 10 to 12, water becomes toxic to most fish. Moreover, the production of too much algae may lower DO in the night, thus posing some harm to aquatic life.

Water quality for aquatic life can be heavily influenced by water regulation measures, such as dams, dikes, and the restructuring of the river bed. Such measures not only influence water quality by dampening seasonal flow variation but they also affect flow variations over the length and breadth of the river bed. This means that habitat availability and variation in space and time become diminished. For example, dams may prevent migratory fish species from moving up or down stream.

Aquatic life (principally fishes and other aquatic flora/fauna) and wildlife are discussed together in this section, as water quality adequate for fisheries in general also means water quality that is appropriate for wildlife (and cattle, too). This notwithstanding the fact that for water organisms (unlike many wildlife forms), water is the environmental medium that serves as their habitat.
**SOURCE: TROMP*

Water quality standards

Standards are formulated by regulatory agencies to define the quality requirements for water streams and water bodies. As such, they are generally based on national laws and regulations. The more specific, the better standards can be linked to measured data. Thus, national standards seem the first choice. In case they are lacking, the general guidelines and standards incorporated in the GEMS/Water programme or those provided by WHO might be used. These general guidelines and standards can then be fine-tuned according to the countries' needs.

different levels of water quality and purity are required for different types of water use. Each water use category has its own quality criteria for assessing suitability. The highest standards of purity are those required for drinking water. In comparison, less stringent water quality standards are acceptable for water used for industrial cooling purposes.
For various uses, water quality guidelines have been developed on ecological, bacteriological and toxicological grounds. Actual guidelines and standards in use in different countries may differ as to quantity of variables covered and threshold values assigned; also, use categories may be defined differently across countries.

Table **W6-W8**

Tables W6-W8 ask for information on the water quality of selected rivers, lakes and coastal areas as measured at selected measuring stations. The tables include the most frequently measured parameters of ambient water quality, for which the annual mean concentrations are to be reported, accompanied by information on the selected water body and measuring station. The selection of the water bodies should be based on their national (economic, demographic, geographic, hydrologic) importance and on the quantity and quality of available measurements. The selection of the measuring station should be based on the availability of longer time series of measurements. Please duplicate the tables if you can provide information for more measuring stations/water bodies.

Table w6 water quality of selected rivers

Name of River A: _____ **Minimum:** _____

Name of Measuring station: _____ **Maximum:** _____

Distance to mouth or downstream frontier: _____ **km** **Sampling depth:** _____

Priority	Category	Unit	1990*	1995*	1996	1997	1998	1999	2000	2001
!	Annual average flow	m^3/s								
!	Biochemical oxygen demand (BOD5)	mg O_2/I								

!	Dissolved oxygen (DO)	mg O_2/I								
	Chemical oxygen demand (COD)	mg O_2/I								
	Total dissolved solids (TDS)	mg/l								
	Total phosphorus	mg P/l								
	Total nitrogen	mg N/l								
	Faecal coliform	MPN/100ml**								
	Other, specify ……	……								

Table w7 : water quality of selected lakes

Name of Lake A: _____ **Minimum:** _____

Name of Measuring station: _____ **Maximum:** _____

Surface area: _____ **km^2** _____

Mean depth: _____ **m** _____

Maximum depth: _____ **m** _____

Sampling depth: _____ **m**

Priority	Category	Unit	1990*	1995*	1996	1997	1998	1999	2000	2001
!	Chlorophyll-a (Chl-a)	mg chl-a/l								
!	Biochemical oxygen demand (BOD5)	mg O_2/I								
	Chemical oxygen demand (COD)	mg O_2/I								
	Total dissolved solids (TDS)	mg/l								
	Total phosphorus	mg P/l								
	Total nitrogen	mg N/l								
	Faecal coliform	MPN/100ml**								
	Other, specify ……	……								

Table w8: water quality of selected coastal areas

Name of the estuary/coastal location: _____ _____ _____ **/year**

Name of Measuring station: _____ _____ **/year**

Mean depth: _____ **m** _____ **m**

Maximum depth: _____ **m**

Priority	Category	Unit	1990*	1995*	1996	1997	1998	1999	2000	2001	2002
!	Chlorophyll-a (Chl-a)	mg chl-a/l									
!	Biochemical oxygen demand (BOD5)	mg O_2/I									
	Chemical oxygen demand (COD)	mg O_2/I									

	Total phosphorus	mg P/l									
	Total nitrogen	mg N/l									
	Faecal coliform	MPN/100ml**									
	Other, specify ……	……..									