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Research and Technical Notes

Obstacles and Chances to Cut Pollution Load Discharges from Urban Palestine

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***Abstract**: This paper presents the results of a descriptive study on assessment of pollution loads discharged from three areas in Palestine. The difficulties and chances to reduce pollution loads of combined municipal sewage and urban stormwater discharges are discussed. Major obstacles behind a poor sewage infrastructure in Palestine were identified as the followings: insensitive Israeli environmental policy now and during the past period of occupation, lack of financial and technical human resources, and insufficient maintenance of sewage facilities, poor environmental awareness, and commitment. The result is a severe negative environmental impact on the aquatic environment and public health. Through personal contacts, actual data on the sewage infrastructure facilities of three representative large cities in the West Bank (Jenin, Albireh, and Hebron) are presented and discussed. By 2005, about 255,000 inhabitants will be living in the three selected Palestinian large cities (Jenin, Albireh, and Hebron). The total annual organic (BOD) and inorganic (NH_4-N) pollution loads from Albireh and Jenin cities are 3,500 t and 850 t per year. This annual pollution is exacerbated through the Israeli settlements, which has been estimated to reach a pollution load of about 400,000 population equivalents (PE). The estimated load emissions in BOD and nitrogen from Albireh sewage works are 3 and 35 percent of the initial pollution loads, respectively. A summary of the urgent research priorities to minimize the pollution loads and measures to abate the negative impacts on the aquatic environment and public health is provided.*

***Keywords**: pollution loads, urban Palestinians, sewage infrastructure, West Bank, research needs, aquatic environment, public health, wastewater treatment*

Introduction

During the past Israeli occupation period for the West Bank and Gaza, the majority of public services in urban and rural Palestine have not been functioning reliably, inevitably affecting the quality of civic life. Of all public services, water supply and sanitation are often given low priority, mainly because disruptions and deficiencies have neither an obvious and direct effects on the public health, nor cause a public outcry. In the urban and rural areas under the Palestinian Authority rule, the local authorities are aware of the poor level of services being provided, however, they compromise for the sake of urgency and because of the lack in human and financial resources. Several studies on sanitation and public health-related issues have shown initial signs of deterioration in public health, in the aquatic environment, and in aesthetic conditions in the majority of cities and towns of the country (Mukhallalati and Safi, 1995; Alawneh and Al-Sa`ed, 1997; UNEP, 2003). However, only a few aid projects have been initiated to date to try improving the present status of water and sanitation systems in Palestine (USAID, 1997).

It is considered important, however, to re-assess the current sanitation situation and suggest appropriate solutions, which are in keeping with the prevailing local economy, available funds, human resources, and political constraints. Accordingly, this study was carried out to investigate the obstacles and chances of organic and inorganic pollution loads minimization from urban Palestine. Based on geographical and sewage treatment facilities, three urban cities from different Palestinian districts are investigated: Jenin, Albireh, and Hebron.

Wastewater Quantity and Quality

Groundwater forms the sole water supply source for all Palestinian districts. Excluding unaccounted for water (average water loss from networks is 35 percent), the average daily urban water supply for 2002 reached 85

Table 1. Present and future annual wastewater quantities (Tahboub, 2000; PWA, 2003)

City	Planning Horizon: 2005				Planning Horizon: 2020			
	Population Total	Sewer network Served (%)	Wastewater (Mm^3/yr) Collected	Wastewater (Mm^3/yr) Treated	Population Total	Sewer network Served (%)	Wastewater (Mm^3/yr) Collected	Wastewater (Mm^3/yr) Treated
Jenin	48,535	70	1.18	1.18	184,450	60-90	3.45	3.45
	Planning Horizon: 2005				Planning Horizon: 2020			
Albireh	43,939	70	1.06	1.06	66,447	90	2.62	2.62
	Planning Horizon: 2000				Planning Horizon: 2025			
Hebron	136,164	65	2.3	0	306,255	95	12.93	12.93

liters per capita. It is assumed that about 90 percent of the water supply will become urban sewage (PWA, 2003). The major published and unpublished data on the quantity and quality of wastewater in three urban communities (Jenin, Albireh, and Hebron) are critically reviewed and analyzed. The criteria for selecting these urban cities are geographic location, population number, wastewater quality, status of sewage treatment facilities, receiving water bodies, and institutional issues. Located in the north, Jenin municipality has an old sewage treatment plant that is overloaded. Hebron City, located in the south part of the West Bank, has no sewage works but a sewage master plan. Finally, Albireh municipality, located in the middle, has a newly-erected, modern sewage works. Based on design reports and unpublished data, the present and future wastewater quantities from these cities are summarized in Table 1. Planning horizon is the planning period for which the treatment plant is designed.

The wastewater quantities were taken and modified from the water sector strategic planning study (PWA, 2003) and work of Tahboub (2000) and Sarhan (2002). In the Gaza Strip, as in all other Palestinian districts, approximately 70 percent of water demand is utilized in agricultural sector. Sarhan (2002) reports that proper treatment and adequate reclamation of urban wastewater (25-75 percent) will provide additional water resource for agricultural and domestic uses for the next 15 years (Figure 1). However, the present situation of sewage treatment facilities in Jenin and Hebron cities will not allow utilizing the treated effluents for technical reasons. Table 2 shows

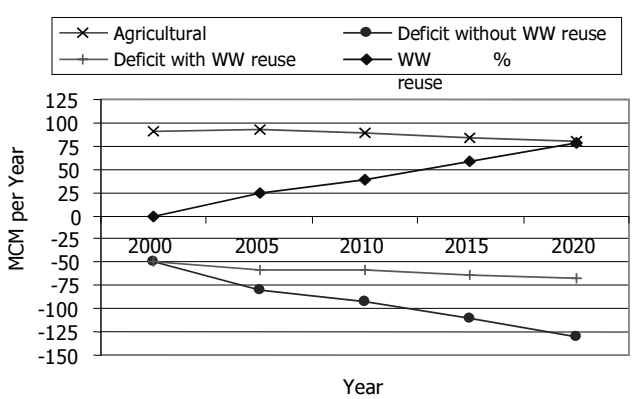

Figure 1. Present and future agricultural water supply balance with and without wastewater reuse

the present pollution loads from the urban cities under study. Tremendous organic (BOD) and inorganic pollution loads (N and P) are discharged either as partially treated, as in Jenin, or untreated sewage, as in Hebron city.

The main pollution load is of domestic origin (population). Mahmoud et al. (2003) have investigated the specific pollution loads (g/capita/d) in Albireh city and reported ranges for COD, TKN, and P (166 to 418, 5.9 to 13.0, and 0.7 to 1.9, respectively). However, the variations in these pollution loads are due to different types of industrial establishments discharging directly into public sewer without prior treatment. The lack of quantitative data on pollution loads from industrial and agricultural sources makes it difficult to estimate the pollution loads discharged into combined sewer overflows and agricultural drainage systems. However, the percentage of hydraulic flow from the municipal daily flow is in the range of 5 to 10 percent (Al-Sa`ed, 2003). Most industrial enterprises are family owned and have no pretreatment systems. In Hebron City, the pollution load in suspended solids is very high because of stone cutting sites. Industrial wastewater will have a negative impact on the sewage treatment facilities. Therefore, each city must have an industrial cadastre plan and should have guidelines for industrial effluents to be served by the public networks. To achieve a sustainable and reliable function of sewage treatment facilities, the design of planned sewage works should take into consideration the pollution loads from the industrial and commercial sites.

Taking the data on pollution loads from the urban Palestine one can imagine how polluted the receiving water bodies are, namely the nearby wadis and natural environment (Figure 2). Adding the pollution load emissions from the

Table 2. Annual organic and inorganic pollution loads (tons)

	Suspended Solids	BOD_5	Nitrogen (N)	Phosphor (P)
Jenin	*Planning Horizon: 2005*			
Collected	868	744	124	37
Treated (%)	50	40	20	15
Albireh	*Planning Horizon: 2005*			
Collected	786	764	90	56
Treated (%)	97	97	63	71
Hebron	*Planning Horizon: 2000*			
Collected	37,595	2,300	639	46
Treated (%)	0	0	0	0

Israeli colonies, it was estimated that about 2,000 km of wadi beds are heavily polluted in the West Bank (PWA, 2003).

Assuming an average wadi bed width of 2 m, the estimated polluted land space is equivalent to about 5 percent of the total irrigated agricultural land in the West Bank or almost all irrigated agricultural land in the Jenin District. The self-purification capacity of wadi beds (seasonal streams) is almost exhausted in terms of biochemical activities. Revitalization of some large wadi beds as groundwater recharge zones and recreational sites is very urgent (Figure 3).

Nwahda and Al-Sa`ed (2001) show that nutrient rich treated effluent (N and P) from the Albireh municipal wastewater treatment plant that got combined downstream with the untreated domestic sewage from the nearby Israeli colonies caused an increase in the turbidity of the raw water source and excessive algal growth in Aqbat Jaber water treatment plant (WTP), which applied the slow sand filter technology. The influent of the WTP is the Ein-Alquilt spring system as a raw water source to provide about 5,000 inhabitants in Aqbat Jaber refugee camp in Jericho district.

Wastewater Treatment Systems

Past and Current Status

Several reports have reviewed the past and current status of sewage infrastructure in Palestine. However, no attempts were made to study the efficiency of the existing sewage works. Some plans for upgrading the current sewage works were prepared without comprehensive technical evaluation of process performance of the current sewage works (Pokelmann, 1997; MOPIC; 1998; PWA, 2003).

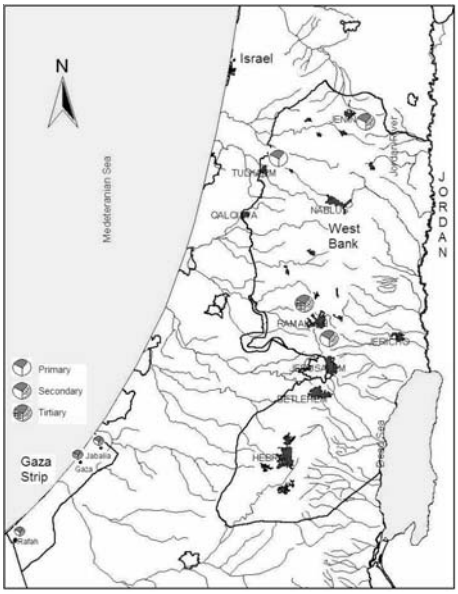

Figure 2. Location of urban sewage treatment plants in Palestine (PWA, 2003)

Figure 3. Wadi Zomer receiving municipal untreated wastewater from the western area of Nablus city in the West Bank (heavily polluted with stone cutting and leather industries)

It is well known that all existing sewage treatment plants are overloaded. Hence the treated effluents do not comply with international effluent quality guideline. The main reasons behind this are:

- Failure in process design, construction, and operation;
- Lack of skilled operating staff and insufficient monitoring programs;
- Weak management and absence of environmental awareness;
- Lack of legal structures and poor enforcement measures;
- Public sector institutional problems;
- Poor maintenance and weak financial resources;
- Low level of public involvement and lack of financial commitment.

Objectives and Choice of Treatment Technology

Effluent quality guidelines of sewage works are still lacking in Palestine. In the past, old urban sewage treatment facilities were designed to serve the objectives assigned by the Israeli Ministry for Environment, where viable effluent quality objectives were defined. Recently, more stringent effluent quality standards were defined for the design of newly-erected and future-planned sewage treatment plants in the urban Palestine.

The wastewater treatment objectives are dependent on the requirements from the receiving water bodies and not on common effluent standards. In some countries, effluent requirements have been explicitly connected to a particular treatment technology. However, more recently, wastewater treatment plants are able to cope with almost any effluent quality objective. The problem is that the cost of such treatment technologies becomes very high since costs increase rapidly with the more stringent effluent re-

quirements (Harremoës, 1997). Recent results obtained by Abu Sharbak et al. (2004) on the annual capital expenditures and running costs of an urban low loaded oxidation ditch serving 32,000 inhabitants revealed that about 1 US$/$m^3$ of treated wastewater is needed to achieve an effluent of international quality.

The definition of effluent quality objectives should allow us to quantify the ultimate cost and benefits for the design and operation of a selected treatment technology. It is also important that an objective function has to be flexible and able to reflect the consequences of different changes (doubling of energy price or water consumption increase) and local site conditions (Abu-Rizaiza, 1999). Historically, sanitary problems were the main reason to develop wastewater treatment facilities. The practical developments in design, construction, and operation of the sewage collection systems (modified, separate, or combined) were to minimize public health risks (Froese and Kindzierski, 1998).

The Role of Wastewater Characteristics and Treatment Technology

Wastewater characteristics have great impact on the type, process reliability, capital and running costs, objective and treatment efficiency of a sewage treatment plant. Also the quality of biosolids produced and their intended final disposal are affected by the quality of wastewater. Therefore, it is crucial to determine and analyze the wastewater quality of a given community before making a final decision on the type of treatment processes. In order to make a proper design much more information is required with respect to wastewater flow, type of analysis, fractional components, and statistics of daily and seasonal variations (Mahmoud et al., 2003).

Due to low water consumption rates in both urban and rural Palestine, the wastewater characteristic is of a high strength nature. Depending on the capacity of the planned sewage works the selection of treatment process might be affected. In western Europe and countries like Germany, there are guidelines for the type of treatment based on population served. The anaerobic sewage treatment is preferred for sewage works serving a population of more than 50,000 population equivalent (PE).

Pretreatment of high strength wastewater can be achieved by applying the Upflow Anaerobic Sludge Blanket (UASB) technology (Ali et al., 2004). A post treatment stage is required to achieve advanced treatment with respect to nitrogen and phosphorus removal (Fuqaha and Al-Sa‘ed, 2004). Biogas utilization and nutrient recovery are major advantages of this type of technology compared to conventional treatment systems (suspended growth and fixed film reactors).

Tahboub (2000) investigated the feasibility UASB technology for wastewater treatment in Hebron City. Compared to conventional suspended growth systems (aerobic and anaerobic) the UASB was most cost effective under the same assumed treatment objectives. About 30 to 50 percent of the energy required for aerobic treatment (oxidation ditches) can be supplied through biogas utilization produced by the UASB technology. The cost for electrical power, a cost factor among the running costs, is very essential, where the Palestinian National Authority still lack its own electrical power generation facilities. The future rise in electrical power is also an important factor, which must be taken into consideration when selecting a treatment system.

Since the capital costs of sewage works is affected by the wastewater quality, some funding agencies in Palestine do not take this into account. The key element in their funding policy is to reduce their share in financial support. Hence, they may play a negative role in selecting the proper treatment technology and further affect the project sustainability.

Wastewater reuse and biosolids disposal options are crucial in the selection of wastewater treatment systems. Most of reports on sewage treatment plants contain a non-comprehensive part on wastewater reuse aspects; however, the biosolids disposal management is seldom tackled. Lack of guidelines and regulations might hamper the proper and adequate selection of wastewater treatment technology. Willingness of farmers to pay for the reclaimed effluent plays a major role in any planned wastewater reuse project (Abu Madi et al., 2003). Moreover, proper operation and maintenance and availability of equipment spare parts are essential for sewage works sustainability (Al-Sa`ed, 2003).

A platform for the current research needs on urban sanitation should be developed, where the priority is given for the following research areas:

- Monitoring of urban wet weather flows (WWF) and combined sewer overflows (CSO);
- Impact of WWF and CSO discharges on receiving water bodies;
- Socioeconomic and public health risk assessment using cause-and-effect linkages;
- Deriving models and simulation related to data base and GIS tools;
- Long term ecological and experimental urban water shed management approach;
- Onsite control strategies and collection system control;
- Innovations in low-cost and high-tech wastewater treatment alternatives;
- Effluent quality standards and biosolids disposal options;
- Onsite and local infiltration systems for both stormwater and treated effluents; and
- Overall effect of automobile on highways and Israeli by-pass roads

It is estimated that US$ 2 to 4 million per year in research efforts is needed to fund the above-mentioned research areas. Because of the political situation in region and because of financial constraints, it is very difficult to predict an adequate time frame for the implementation of the above suggested research areas. The most urgent preconditions for the implementation of the above-mentioned

platform is to establish a set of environmental rules and guidelines for the compliance requirements including the application of these rules and guidelines to the various receiving water bodies (both surface water and groundwater) in Palestine. It is also suggested that not only should the environmental impacts from rural and urban sanitation systems be evaluated, but also all other forms of sanitation facilities including landfill sites, industrial sites and stormwater sewer overflows.

Pilot Plant Studies and Planning Horizon

Pilot plant studies are very important to gain process design data and to test the process performance and cost effectiveness of a selected treatment technology. Albireh and Nablus cities have conducted their own pilot plant studies. The pilot plant in Nablus City failed, and the obtained process design data were not utilized in the planned sewage works. As the data obtained were not reliable, the pilot plant did not function effectively. In addition, the results from the pilot plant in Albireh City were not utilized to design the final sewage treatment technology. The ineffective institutional coordination, inadequate design and operation of the pilot plants, and the strong influence of funding agencies played a key role in the failure of achieving the major aims of conducting pilot scale studies.

The political situation and financial resources in Palestine have a great impact on successful implementation of sewage treatment facilities. The planning horizon for which a sewage facility is designed (20 years) and the final design phase for Albireh sewage treatment plant was ready after about six years. Another two years were needed to build the sewage works and put it into operation. If this is the case, there will be only about three sewage works in the coming next 25 years, which contradicts the major aims of the wastewater sector strategic plan of the Palestinian Water Authority (PWA, 2003).

Institutional Sector and Legal Structures

The PWA is the institution in Palestine that is responsible for the water and wastewater sectors. The Ministry for Environmental Affairs is responsible for water-related pollution control issues and coordinates with the PWA in issuing regulations and guidelines.

The institutional structure of public water sector including the technical and managerial staff is still weak. The current situation reflects the misconceptions about and the inadequate wastewater infrastructures in Palestine. The political and economical situations as well as the weak inter-institutional coordination exacerbate this fact (Theodory and Al-Sa`ed, 2002). The academic institutions play a key role in feeding the Palestinian institutions with sufficient technical staff. However, personal relationships sometimes rule the appointment when there are open job vacancies.

It is not sufficient to have environmental law and guidelines without having an effective enforcement tools and alternatives. Although we have a Palestinian Environmental Act, it includes different environmental sectors, only one of which is the water and wastewater sector.

Costs and Environmental Impact of Wastewater Treatment Plants

According to UNEP study on Palestinian environment, it is underlined that, uncontrolled landfill sites and inefficient sewage works may pose not only risks to human health but also may have serious negative impacts on biodiversity. Nutrient-rich (N and P) effluent causes eutrophication of wetlands, and high BOD causes changes in ecosystem functions and loss of species along wadis flow. The Wadi Al Nar in Bethlehem district receives untreated municipal discharges from Palestinian cities and from nearby Israeli colonies and flows for about 30 kilometers before reaching the Dead Sea. There has been an increase in pest species and scavengers at exposed solid waste sites and untreated sewage outflows. Liquid waste containing pesticide residues and heavy metals might increase toxins in food chains and exert significant potential threat to biodiversity in the region (UNEP, 2003). Annually, about US$ 10 million are deducted from the Palestinian taxes by the Israeli Ministry for Finance as a pollution levy (a legally-controversial issue) raised for treating the Palestinian raw and partially-treated effluents received by Israeli water bodies (PWA, 2003).

To reduce industrial pollution loads within the heavy polluters can be achieved through cleaner production application, waste recycling, and environmental management policy adoption. Nazer et al. (2004) show that reuse of raw industrial discharge of unhairing-deliming process within the leather industry can reduce the organic pollution load and minimize the hydraulic flow five-folds without affecting the leather product. However, small enterprises cannot apply cleaner production principles as they lack technical and financial resources. Hence, the planning and construction of wastewater treatment facilities for both rural and urban areas is a priority to reduce the impacts of pollution loads, and this is incorporated within the policy of the Palestinian Water Authority. However, it is very difficult to suggest a time scope to implement the proposed measures due to prevailing political and economical situations.

All master plan projects in the sewerage infrastructure provide capital investment costs and estimations on specific costs for wastewater treatment. However, these studies made neither a detailed economical analysis nor comprehensive environmental impact studies. Sometimes the specific treatment costs (US$/m^3) are based only on the annual running costs without taking into considerations the annual capital costs. The investment costs of a sewage works is not the limiting factor, but the annual capital and running costs, which must be tolerable by the community served. Moreover, while calculating the annual costs the financial aids by donor countries must not be deducted from the total investment costs. Detailed data and recommendations on costs analysis and sustainability of the

wastewater treatment facility in Albireh city are reported by Abu-Sharbak et al. (2004).

Conclusions

It would be easy to be critical of the present sanitation infrastructure for failing to provide the Palestinian communities with technologies and infrastructures that are not capable of supporting changing economic, social, and environmental patterns. However, this paper has made an attempt to define the past and current obstacles in reducing pollution loads from the urban Palestine. It is proposed that progress towards pollution reduction and aquatic environment improvement by adopting the followings:

- Implementation of proper sanitation plans can reduce and control pollution sources;
- Close inter-departmental and inter-institutional coordination must be a national strategy;
- Technical, financial, and environmental review of sewerage infrastructure development projects should be made by independent institutions;
- Legal structures and enforcement measures are key elements for successful implementation;
- Capacity building in the water sector and strengthening institutional human resources are crucial for sustainable management of sanitation infrastructures;
- Professional, applied research and technical skills training should be conducted and financially funded through governmental and private institutions;
- Community involvement and its financial contribution would enhance the sustainability of sanitation infrastructures; and
- Sustainability should be an integral part of urban sanitation infrastructure development.

The problems in reducing pollution loads from urban sanitation systems have to be solved in close cooperation among various national and regional institutions and disciplines. It is of profound importance that the people have a common platform and language for communication and cooperation.

About the Author

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