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PRODUCTION OF BIOLOGICALLY STABLE WATER THROUGH PROCESS PERFORMANCE ENHANCEMENT OF JERICHO WATER TREATMENT PLANT IN PALESTINE

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ABSTRACT

Since the establishment of Jericho Water Treatment Plant (JWTP) in 1956, around 500 m^3 of drinking water per day are produced for more than 5000 inhabitants living in Aqbat-Jabr. Water spring at Wadi Qilt is considered the main raw water supply for the JWTP. It is operating fairly in summertime under poor management and lack of maintenance. The present treatment process entails slow sand filtration and disinfecting processes. In rainy days the influent fecal coliforms are about 800 colonies/100 ml, which are significantly above those recommended by the WHO. The turbidity is more than 30 NTU; extensive growth of algae in feeding open canal and in the slow sand filters is visible. The water of Wadi Qilt springs is polluted while flowing in the open canal more than 13 km long to JWTP. From 1997-1999, a few incidents of water-borne, diseases were reported because of inadequate filtration and interruption of the process of the disinfecting. JWTP is the only major source of drinking water for Aqbt-Jabr, but failure of the treatment process at JWTP in wintertime forces the operators to close the facility and look for other sources. The objective of this paper is to identify pollution sources and provide protective measures for establishing a water treatment system, which will produce a biologically stable, treated effluent, especially during winter season. Physico-chemical and biological analysis on raw water at different sampling station of Wadi Quilt and treated water of JWT were conducted. A pilot-scale sand filter with a settling tank was constructed to simulate the present unit operations of JWTP. The analytical results conducted on the experimental SSF model suggest that a settling tank with pre-chlorinating unit must precede the existing unit operations of the water treatment. After executing the modifications on the experimental SSF model, the efficacy of removing turbidity has reached 85%, no algal growth was observed and no faecal coliforms were detected.

KEYWORDS

Water treatment, algal pollution, faecal coliforms, slow sand filters, turbidity, slow sand filter

INTRODUCTION

Palestine, as other semi-arid Mediterranean countries, suffers not only from water shortage but also the available scarce water resources are experiencing a gradual degradation in the water quality. According to the last Palestinian census (PCSB, 1999) about 150 Palestinian communities do not have access to a central drinking water supply. The public health is negatively influenced through lack of central sanitation systems and waste disposal facilities. Municipal wastewater either untreated or partially treated in overloaded existing urban

sewage works as well as urban storm water runoff are among the main pollution sources for groundwater and fresh water springs (Al-Sa`ed, 2000).

The main source for domestic water supply in Palestine is groundwater. Little efforts were done to utilize the pristine water from large water springs. The only single water treatment plant in the West Bank is Jericho Water Treatment Plant. In Jericho district, the current average of domestic water consumption is less than 100 liters per capita per day. Technical proposals were made to transport that water through pipes instead of using the open canal. However, due to financial constraints and other related environmental consideration, these proposals were not implemented.

The treatment plant works properly in summer, but since 1997 the operation of the treatment plant has been stopped in winter period. Figure 1 shows the location of the study area. The water treatment plant consists of three main slow sand filters (SSF), where one filter of these is acting as a stand by and a chlorinating unit. The main aim of this paper is to investigate sources of pollution and introduce possible technical methods to produce a stable biological treated water suitable for human consumption.

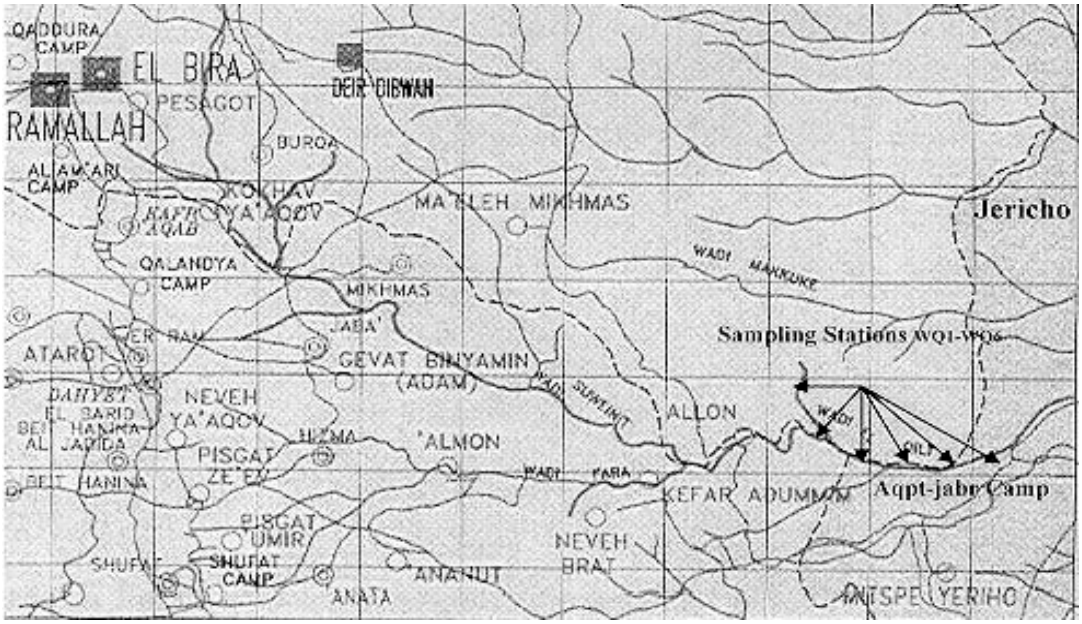

Fig. 1 Location of study area

MATERIALS AND METHODS

Fieldwork has been carried out in Jericho from September 1998 to April 1999. Local data of the existing water system and water treatment plant JWTP, urban development, qualities and quantities of raw water at Wadi Qilt have been collected. Analytical fieldwork includes physical, chemical and biological analysis of raw water in the open canal at Wadi Qilt. In order to identify pollution sources, and water quality, six sampling stations were selected along the open canal in Wadi Qilt, starting from Fawar Spring and ending at JWTP.

Composite and grab samples from the influent of the slow sand filters and from the water supply reservoir were taken respectively. The analytical and preservation methods were according to standard methods for examining water and wastewater (APHA, 1992).

To simulate the function of the existing JWTP, a small pilot scale experimental model of slow sand filters was self constructed preceded by a small settling tank.

Settling tank

A circular settling tank, made of PVC plastic was designed to produce a pretreated raw water flow rate of 32.72 L/h. By a tank diameter of 0.56 m, the minimum average settling velocity (0.38 cm/s) to achieve a 100 % removal of flocs in the settling tank was calculated.

SSF experimental model

Amended influent raw water to the SSF with pollutants was prepared in order to simulate the real water characteristics, during winter days, at the inlet of JWTP. Raw water samples from Wadi Qilt springs were amended with pollutants to simulate the actual water quality during winter season as follows; polluted with domestic wastewater, polluted with manure and wastewater from livestock farm, soil polluted, temperature 10 ^{o}C and turbidity of 50 NTU

Design of the SSF experimental model

The filtration rate is designed to be between 0.1 and 0.2 m/h to ensure adequate filtration process. The design data of the settling tank and SSF model are summarized as follows:

Settling tank:

Volume: 400 L

Slow sand filters:

Total volume: 400 L
Barrel diameter: 0.56 m
Barrel area: 0.24 m^2
Flow rate: 32.73 l/h

Filter media: Sand 250 L, grain size 0.15-0.35 mm, Gravel 60 L; 20 L, grain size 0.4-3.3 mm; 20 L, grain size 3.3-6 mm; 20 L, grain size 6-12 mm.

Construction and operation of pilot scale plant

The SSF experimental model is made of two PVC plastic barrels, each of which holds 200 liters: one stacked on the top of the other, making a total height of 180 cm. Then four holes were cut in the barrels. Figure 2 shows the two plastic barrels where the influent valve is installed at 135 cm high from the bottom. The effluent hole is 6 cm high from the bottom, the scum valve is 170 cm high from the bottom, and the drainage valve is 85 cm from the bottom.

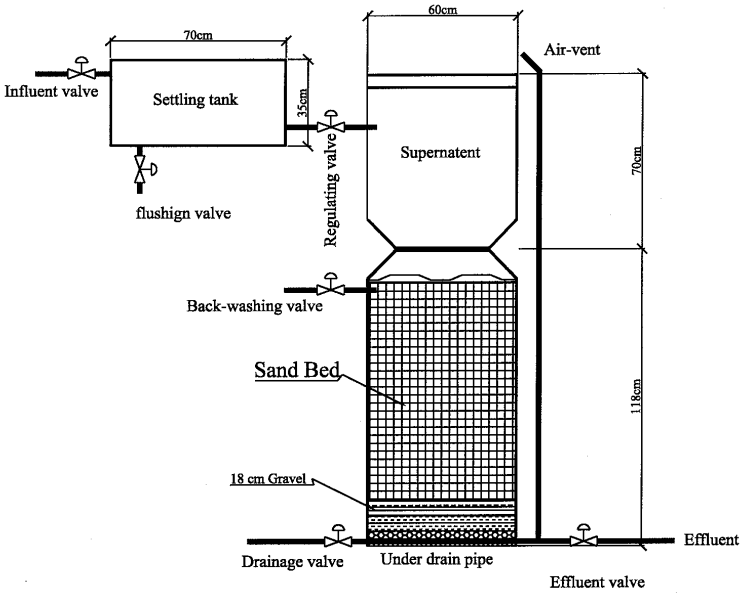

Fig. 2 Schematic flow diagram of the SSF experimental model

The water drain system consists of the gravel that support the sand layer and a plastic pipe is perforated with a 3 mm bit to be the under drain pipe, connected to the effluent valve. Then the lower barrel is filled with sand for a total height of 100 cm. Small tiles are placed on the surface of the sand bed to prevent erosion of the sand bed. To remove air pockets from the sand bed during start up phase, the SSF were fed by an upflow hydraulic mode (Al-Sa`ed, 1997).

RESULTS AND DISCUSSION

The characteristics of the raw water and the efficiency of JWTP were determined. The analytical parameters of interest were: ammonium (NH_4), nitrate (NO_3), ortho-phosphate (PO_4), total dissolved solids (TDS), electrical conductivity (EC), turbidity (NTU), temperature, pH, salinity, chlorine, and fecal coliforms.

Sources of pollution

Observations through the fieldwork conducted on sampling stations along the open canal course revealed the following possible pollution sources:

- Urban storm water runoff, municipal wastewater discharged into Wadi-Swenetta and leachate from solid waste dumping sites are major sources of pollution. Manure and wastewater from animal grazing farms near by the open canal add biological nutrient pollutants and hazardous organic materials to the water stream.

- Local and foreign human recreational activities, such as camping and walking along the Wadi Qilt can cause negative impact on water quality and hydraulic flow properties in the open canal.

- Growth of algae in the open canal in Wadi Qilt is gradually increasing caused by the increase of new residential colonies in the surrounding area, which increase the discharge

of municipal wastewater in the wadi. Phosphorus and nitrate are essential factors in supporting the growth of algae. The concentrations of both biological nutrients in the samples collected from the open canal at the entrance of the JWTP are shown in figure 3.

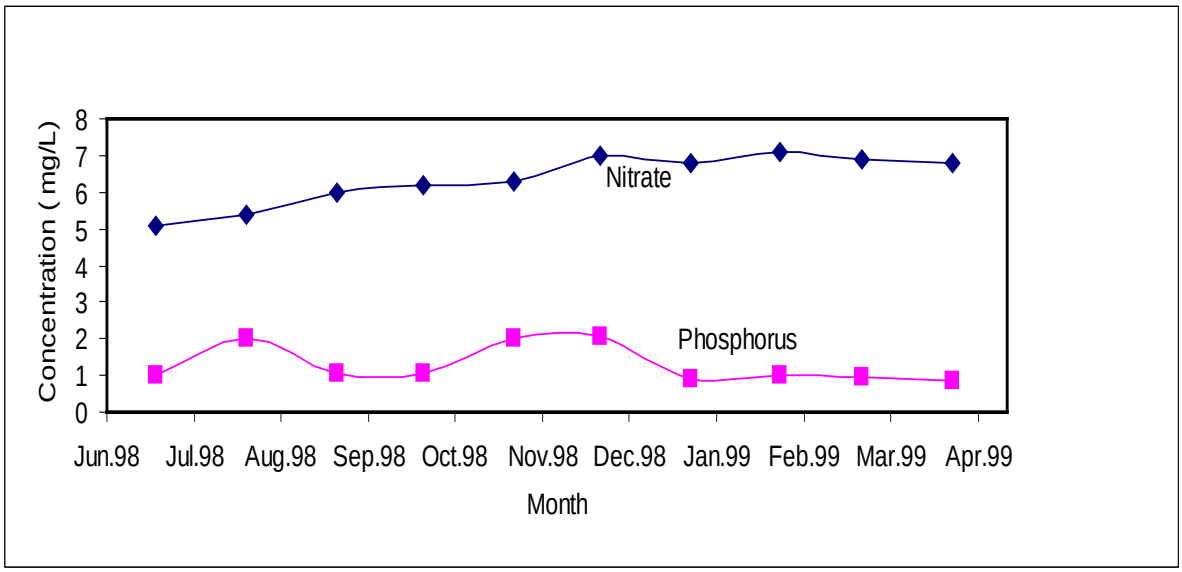

Fig. 3 Phosphorus and nitrate concentration in water samples from the inlet of JWTP

Toft *et al.*, (1988) reported that open water canals, sand filter basins, and water supply tanks are habitats suitable for algal growth, which is mainly affected by the light and nutrients in the raw water. The problems found in JWTP due to algae growth are taste and odor in the treated water, resistance of water flow in the treatment plant, and in the water open canal, filter clogging, algal extra-cellular products and toxins in the water, filter cleaning and algae removal and disposal. To solve these problems, usually the operators used to increase the hydraulic surface over 0.6 m/h to fill the sand filter, however, this will cause sand erosion and enhance short-circuiting in the sand filters.

Water quality of the open canal

The water quality in the open canal, a branch of Wadi Qilt, concrete made and 13 km long, feeding the JWTP was investigated. Water samples were collected from six sampling stations every 2-km along the 13 km open course. The physico-chemical and biological quality analyses are tabulated in table 1.

Table 1: Water quality analysis on open canal samples

Site	pH	T ^{0}C	TDS mg/L	Sal. (%)	EC µs/cm	NO_3^- mg/L	$CaCO_3$ mg/L	Cl^- mg/L	FC / 100mL	Tur. NTU
WQ1	7.01	14.2	442	0.2	800	8.0	0.25	0.03	100	3.5
WQ2	7.03	14.9	446	0.2	805	8.5	0.27	0.03	100	3.7
WQ3	7.12	14.7	449	0.2	805	8.5	0.28	0.03	200	4.2
WQ4	7.22	14.6	452	0.2	817	9.0	0.3	0.02	200	5.3
WQ5	8.01	15.0	461	0.2	830	10.0	0.3	0.02	200	7.0
WQ6	8.02	15.5	470	0.2	835	12.0	0.3	0.02	300	10.5

At the entrance of JWTP turbidity measurements were made on water samples collected

during the study (Fig. 4). During turbidity peaks the operators stopped the operation of JWTP and Mekorot supplied people in Aqbat-Jabr camp.

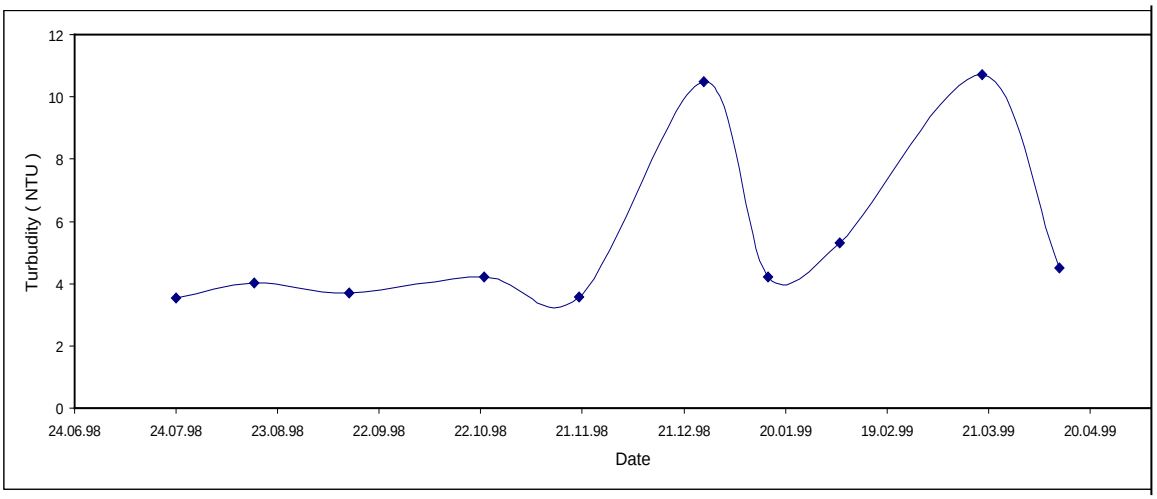

Fig. 4 Variations of turbidity measurements in samples from the inlet of JWTP

The results shown in table 1 and figure 6 indicate that turbidity caused by algal growth and other suspended inorganic and organic substances is the major pollutant. The concentrations of nitrate is below the average (34 mg/L) reported in the literature (Abed Rabbo *et al.*, 1999, Alawneh and Al-Sa`ed, 1996). Turbidity and fecal coliforms increased with down stream flow. Gradual increase in nitrate values along the course of the open canal might be due week nitrification process prevailing under turbulent flow conditions in the open concrete canal.

Turbidity removal

Results obtained from the pilot scale SSF model showed that by turbidity levels above 20 NTU caused SSF clogging. At a hydraulic retention time in the settling tank of 2 hrs the efficacy of SSF in turbidity removal ranged between 80 and 90 at influent with 15 and 5 NTU respectively. Thus a pre-sedimentation stage is essential for the enhancement of the treatment processes in the SSF at low investment (US$ 5000).

Management structure and operation of JWTP

The evaluation of the water treatment plant management program at JWTP illustrates some of the unique problems of conflicting goals and constraints associated with an area under rapid development while facing conditions of scarcity (Shuval, 1980).

The JWTP operation must fulfill the basic requirements suggested by Mutschmann, *et al.*, (1991). All parties involved in the operation and management of JWTP (UNRWA, Aqbat-Jabr Camp Council and technical staff) are responsible for providing a safe drinking water.

CONCLUSIONS

Fieldwork investigations and water quality analysis showed that the main pollution sources in the study area are the municipal sewage discharges at Wadi-Swenetta coming from Al-Bireh city and the Israeli settlements. The water quality analysis showed that the turbidity levels exceeded 20 NTU during winter season and summer time cause process failure and clogging

of the sand filters of Jericho water Treatment Plant.
Reducing the extensive algal growth in the slow sand filters, can be achieved by reducing the sunlight over the sand filters, using plastic covers, or by adding chemicals. Temperature and nutrients enhanced algal growth.

According to the results of the experiments on the designed SSF experimental model, turbidity and coliforms are the main constraints for the operation of a SSF. Turbidity levels above 20 NTU will cause clogging. Fecal coliforms removal requires an efficient disinfecting method. The existing treatment process at JWTP can be operated continuously with a turbidity removal efficiency exceeding 85% by installing a small settling tank at low costs.

Conducting public awareness programs in the sphere of aquatic environment protection, the wise use of water will minimize pollution. A training program must be given to all labors at JWTP in order to avoid operational, managerial problems, and minimize public health risks.

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