

Summaries from Selected MSc Theses in Water
and Environmental Engineering and Sciences



Strengthening Linkages Between Science and Policy Making

Edited by: Maher Abu-Madi- Rashed Al-Sae'd - Nidal Mahmoud - Issam Al-Khatib

May 2014



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Preface

The Palestinian water sector suffers from many physical, political, technical, economic, and management challenges. The physical challenges relate to the natural scarcity of water in the region. The political challenges relate to the Israeli occupation and the regional unrest. The technical challenges relate to the effectiveness and efficiency of the technologies used in the water and wastewater sectors. The economic challenges relate to the high cost of service and limited financial resources including poor cost recovery and conditional external aid. The management challenges relate to the regulations, policies, and institutional functioning in the water sector.

There has been an extensive effort from different local and international organizations to improve the functioning of the water sector in Palestine at all levels of the abovementioned challenges. Nevertheless, sector is still far beyond its optimal performance and efficiency. Besides, the sector suffers from poor interaction between scientific research, policy making, and practice. The academic institutions have substantial effort in the water sector through the research studies carried out by their staff and MSc students.

Our initiative was to start with the MSc thesis reports that have been produced and published by Birzeit University during the past 10 years. We believe that many of them have important findings and relevant key messages that could be translated into advices and recommendations to our national policy-makers. Some of them might also be useful to the local communities and practitioners in the water sector.

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Evaluation of the Municipal Water Supply Systems in the West Bank Statistical Analysis and Identification of the Influencing Factors

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Executive Summary

The preliminary design of any water work requires determining the water demand, unaccounted for water, and a cost estimate study. In most of the cases, the present consumption is already known, but the encountered problem is to estimate the water demand for long periods ahead. This involves an analysis of the factors that may affect the water consumption and the water unaccounted-for by using statistical methods.

The results of this study show that the total community water consumption is highly related with the total number of served houses whilst the surveyed per capita water consumption was 72 l/c.d. Furthermore, the average surveyed unaccounted for water which is highly related to the total number of service meters is found to be 33% or 0.59 m³/(km.hr). Out of 20 questioned municipalities, only 3 municipalities consider their water supply sufficient. Only 50% of the questioned municipalities consider the supplied water quality is very good while the rest municipalities consider the quality of the supplied water is good. The applied treatment method in the whole water treating municipalities is Chlorination.

These results are helpful to the West Bank municipalities and water organizations in determining their future water demands, and unaccounted for water if some or at least one related independent variable is known. On the other hand, it furnishes the high unaccounted for water municipalities with some valuable suggestions to reduce that percentage. There is no clear systematic water tariff among the Palestinian water utilities in the West Bank.

Introduction

Water resources in the West Bank are limited and could be considered as the major constraint to the economic development and the most precious natural resources. It is important to focus on the water researches, especially those related to the water supply, water distribution and water resources management to realize the efficient usage of the valuable resources. The high percentage of the unaccounted for water due to leakage from the old pipes and the illegal connections in addition to the lack of proper sewage collection systems in the most of Palestinian territories severely limits the potential for sustainable development of this resource. Subsequently, the unaccounted for water are ranged between 25-50% in the West Bank. The general goal of this study is to evaluate of the water supply systems in the West Bank. The objectives are: to evaluate and analyze the existing situation of water supply systems, tariff and unaccounted for water in the main cities of the West Bank; to identify the factors influencing the water consumption and water unaccounted for in some cities of the West Bank; to construct the relationships between the factors influencing water consumption and the water unaccounted for in of the West Bank; and to propose a cost estimation relationships for some items of water distribution systems. The design criteria of the distribution systems in West Bank starts by the detailed studying of the factors influencing the water consumption; mainly, population, price of water and metering, climate, standard of living and industries. These are achieved throughout this study.

Approaches and Results

The discussed main parts are statistical analysis of the main factors influencing the water consumption, and the water unaccounted-for. First, a literature review was carried out for the practiced municipality's staffs and water distribution institutions at West Bank, to help in evaluating the current situation of the water distribution systems. Data is collected through a questionnaire and sent to the main municipalities in the West Bank in order to collect necessary data related to the water consumption, unaccounted-for. Afterward, statistical analysis is attained for the collected data to construct the relationships between the water consumption, unaccounted for water and the independent variables.

Metering is applied by all municipal consumers in the all considered municipalities. The surveyed daily per capita water consumption ranges between 15-160

l/c.d in the West Bank with an average value of 72 l/c.d. In other words, 74% of the total population in the West Bank is suffering from the water shortage. And also, 65% of the considered municipalities (13 out of 20) are without sewerage system. The average daily per capita consumption in the sewered communities is 74 l/c/d while the average daily per capita consumption for the unsewered communities is 46.0 l/c/d. The total daily community water consumption (m^3/day) statistically correlates highly and positively with the number of sewered houses, population, total number of service meters, parks and empty areas, the total number of houses and the annual average annual temperature increase and inversely with the average water unit price.

The unaccounted for water ranges are between 13 – 40 percent with an average value of 33%. The water unaccounted-for statistically correlates very high with the volume of water delivered to the city or town, number of service meters, total length of the distribution system, number of public fountains, and total number of mosques, hospitals, public toilets and paths. In addition, the inadequate distribution system monitoring and maintenance are important factors contribution to unaccounted-for water.

The average unit of water price (tariff) in the West Bank is 2.7NIS/ m^3 . In Nablus municipality, the unit water price reaches 4.3NIS/ m^3 due to the high percentage of leakage in the network, difficult topography and the upstate location of the municipality resources. On the other hand, due to the nearness of the water resources and the simple topography the water unit price in Jericho district reaches the minimal value of 1.0 NIS/ m^3 .

The operation and maintenance cost for the distribution system could be estimated according to the total water delivered, and the cost of the most economically distribution pipes could be estimated according to diameters. The cost of both elevated and on ground reservoirs are estimated according to the volume of the reservoirs.

Conclusions

The daily per capita water consumption highly depends on the annual average community temperature and inversely with the average water unit price. The total community water consumption is highly dependent on the population and the total number of served houses. The average value of the unaccounted for water for the questioned communities in the West Bank is 33% or 0.59 $m^3/km/hr$. Water unaccount-

ed for highly dependent with the total water delivered, the total number of service meters, distribution system length and the total number of public facilities. The high percentage of unaccounted for water which is due to the length of the distribution system is 83% that means the leakage through the system itself is large. The rest of unaccounted for water percentage for is due to the under recording meters and due to unmetered public facilities or fountains.

Implications and Recommendations

- Municipalities (i.e. Qalqiliya and Jericho) must restudy their water tariff to reduce their water demand in order to contribute in the total demand coverage in the West Bank with their extra water resources.
- Encourage newly heavy water consumption industries to invest in the cities with sufficient water. Encouraging the off peak hour water consumption for heavy consumers by reducing the rates charged for water during the off-peak-hours.
- The water consumption must be metered for the all consumers, and the water meters must be calibrated and maintained on a regular basis. Install a central community water meters for the all served communities, and zoning the metering for the large communities.
- For the municipalities with high UFW/km/hr, the regular maintenance and network inspection is required and metering all public facilities is recommended.
- Other studies can be carried out for the actual effects of the water quality and pressure on the water consumption.

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Executive Summary

The continuously increasing demand for fresh water requires the enhancement of environmental conditions surrounding the cistern owners' awareness to tackle the mismanagement that contributed to rainwater contamination. In this study, 100 cisterns are sampled and tested for physiochemical and microbiological parameters. Most of the tested physiochemical parameters are within the acceptable limits of WHO and Palestinian standards except turbidity, calcium and magnesium where 24%, 47% and 32% of the samples are nonconforming, respectively. The pH values of the collected rainwater ranged from 7.32 to 8.97 with a mean value of 8.16. The nitrate analysis results range from 1.5 to 7.0mg/L, with a mean value of 4.2mg/L. High percentage of cisterns are found to be contaminated with total Coliforms (TC) and faecal Coliforms (FC) with percentages of 95% and 57%, respectively, rendering the cistern water unacceptable for drinking purposes. 78% of samples had a severe degree of contamination for which water needs flocculation, sedimentation then chlorination to become suitable for drinking. On the other hand, based on FC data, none of the tested samples for FC is a "high risk", but 57% of them are categorized with "simple" to "moderate risk" and 43% are "no risk" cisterns. A cistern owner's survey is utilized to reveal the roots behind this contamination. Different remediation measures, such as cleaning cisterns and rainwater collection surfaces and discarding water from the first season storm, are recommended to enhance and protect the cistern water quality.

Introduction

Palestine is characterized by arid to semi-arid climatic conditions and has very limited accessed water resources. The majority of fresh water supplies in Palestine come from scarce groundwater resources. Future population growth and its associated water demands are expected to place severe pressure on these limited groundwater reserves. An established goal of the World Health Organization (WHO) and its member states is that all people, whatever their stage of development and their social and economic conditions, have the right to access an adequate supply of safe drinking water. Consequently, rainwater harvesting becomes of great importance in the socio-economic development of Palestine, where water sources are scarce or polluted environmental management of rainwater harvesting in southern Palestine is required to reduce the continuously increasing demand for fresh water from limited water aquifers and to reduce the adverse health impact on the people drinking harvested rainwater.

The aim of this study is to assess the management practices of the rainwater harvesting cisterns in southern Palestinian territory, using Hebron city (the largest city of that area) as a sample locality. This is achieved by analyzing the physiochemical and microbiological quality of the harvested water, along with possible causes of water contamination. Improvements of the rainwater harvesting system are then proposed, so as to minimize potential health risks.

Approaches and Results

100 water cisterns in Hebron city are sampled and their owners are surveyed, using a pre-prepared semi structured questionnaire, covering a wide range of cistern management issues as well as environmental conditions surrounding the cisterns. At each sampling site, temperature, electrical conductivity, total dissolved substances, pH, salinity and turbidity of cistern water are measured. At the water lab, water is analyzed for indicator organism concentrations (Total Coliforms and Faecal Coliforms) and other chemical water quality indicators (Alkalinity, Total hardness, Calcium, Magnesium, Chloride, Nitrate and Ammonia).

About 46% of the cisterns are more than 20 years old, and 16% are 16–20 years old. On the other hand, the study shows that a significant number of cisterns (27%) are constructed within the last 10 years, reflecting a growing demand for this alternative water source. As one considers cistern capacity, the highest percentage (35%) of cis-

terns is larger than 100 m³, while the smaller cisterns (less than 20 m³) constituted the lowest percentage (6%). Typically, Hebron residents divert rainwater into cisterns and use this water throughout the dry summer season, and so each cistern is expected to hold an amount of water enough to satisfy minimal requirements during the rainy season and then during the summer season.

The results of temperature, Conductivity, Nitrates, Chloride, Hardness, Salinity and Total dissolved substances are below the maximum levels established by Palestinian and WHO standards, while 24%, 47% and 32% of the samples for turbidity, calcium and magnesium respectively where are nonconforming. Water quality results indicated that 24% of the tested samples had turbidity values exceeding 5 NTU, which exceeds both Palestinian and WHO standards.

In 95% of the cistern samples, total Coliform (TC) is detected, while faecal Coliform (FC) is found in 57% of the tested samples. From the distribution of cistern water samples according to their level of contamination and treatment procedure required, as based on their total Coliform, the highest percentage (78%) of samples had a severe degree of contamination for which water needs flocculation, sedimentation then chlorination to become suitable for drinking. On the other hand, based on FC data, none of the tested samples for FC is a “high risk”, but 57% of them are categorized with “simple” to “moderate risk” and 43% are “no risk” cisterns. Despite the acceptable chemical quality of the cistern, the presence of microbial indicators makes it unsuitable for drinking, at least without treatment.

It is found that the main factors that contribute the microbiological contamination of rain fed cistern water are (1) not cleaning the cistern, (2) not cleaning the water collection surface before first season storm, and (3) not discarding the rainwater from the first storm.

Conclusions

Rainwater harvesting is being actively used in Hebron city, where dependence on seasonal rain necessitates that water be collected and stored where and when it becomes available. The physiochemical quality of harvested rainwater in Hebron city is reasonably satisfactory with only turbidity and magnesium parameters being detected above the corresponding maximum allowable concentration for drinking purposes. On the contrary, microbial indices (total Coliforms and faecal Coliforms)

are detected in the majority of samples, though at low to medium levels. It is concluded, based on the findings of this work, that the surrounding environment, cistern management practices, and the cistern owners' weak awareness of preventing rainwater contamination are the main factors that are contributing to harvested rainwater contamination.

Implications and Recommendations

Rainwater harvesting is an important water source in Palestine and should be encouraged and enhanced. Based on the existence of the microbiological contamination indicators in the harvested rainwater, a number of pollution sources are recommended, which are strongly suggested to be considered as contamination prevention strategies are developed. As a key prevention measure, harvested rainwater should be disinfected (e.g., via chlorination) before usage for drinking purposes.



Monthly Recharge Estimation for the Auja-Tamseeh Catchment of the Western Basin Aquifers-System, Palestine

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Executive Summary

This study aims at developing a monthly recharge estimation model for the ground water system at Auja-Tamseeh surface catchment of the Western Basin Aquifer- Systems in Palestine. The study is based on the hydrological observations developed by thorough analysis of rainfall quantities and their effect on groundwater level rise inside the aquifer. The first hydrologic observation is related to lag-time effect for any rainfall event. Hydrographs of monthly groundwater levels revealed that groundwater level peak usually took place in April except for the very wet year 1991\92 were heavy rain in February and March drifted the peak to June-July. The study assume a three month lag-time period with a groundwater level peak at April. The second hydrological observation is concerned with the accumulation effect of a rainfall event.

The change in the groundwater level is noticed to increase gradually till it reach its maximum effect (peak) at April which is three months away from the maximum long term average monthly rainfall values. The spatial and temporal variations of rainfall amounts impeding on the land surface and the replenishment through the outcropping formations was used as a base for a developed mathematical model. The model equations are used to calculate areal recharge volumes over the Auja-Tamseeh catchment. The percentage of recharge from rainfall volumes is equal to 21 % which is close to findings of other studies like SUSMAQ study of Wadi-Natuf were this percentage was equal to 25.7 %.

Introduction

The Western Aquifer Basin WAB, which covers an area of 9155 km², is the biggest of the Mountain Aquifer sub-basins and has a safe yield of about 380-450 million cubic meters (Mcm)\ year (SUSMAQ, 2001). The WAB is bounded from the east by ground water divide caused by the anticlinal ridges and in the northern part of the WAB is bounded by the Menashe Syncline axis. While the southern and western boundary is formed by the ground water divide.

Approaches and Results

The main objective of this study is to estimate monthly values of recharge which will help in providing a more accurate management plan of the available water resources. The study deal with the Selection of the most appropriate approach of recharge estimation for the area of study by considering the limitations of data availability and development of monthly recharge models for the study area. Data used in the study is of two folds: rainfall data, well abstractions, and spring discharges for twelve consecutive years extending from 1985 to 1997. Statistical methods are used to check the accuracy and estimate rainfall for some of the stations. The average rainfall peak occurred in December and groundwater level peak occurred between April and May.

This supports the delay time effect which is one of the major principles in the study's theoretical approach. The accumulation effect leads to assigning new rainfall accumulated values for each month of the hydrologic year designated by monthly values. The equation used for the monthly recharge as presented by SUSMAQ (2004) study for the Wadi Natuf catchment was: $R_i = (P_{ci} / P_a) * R_a$ (R_i is the monthly recharge for the month i in the year i in (mm), P_a is the annual rainfall for the year that includes month i (mm), R_a is the annual calibrated recharge for the year that includes the month i (mm), P_{ci} is the accumulated rainfall from previous months into month i (mm)).

The calibrated annual recharge model used in calculating monthly recharge accounted for evaporation and runoff losses, thus giving net monthly amounts of water reaching the ground water basins. The produced equations are used to calculate total recharge quantities for the whole catchment in million cubic meters (Mcm) for each month of the hydrological year starting with October of the current year and ending with September of the following year. The Upper Aquifer has the maximum recharge quantity, while Yatta formation has the lowest recharging quantity. Re-

charge took place through the outcrops only which explains excluding some rainfall stations from areal recharge calculations. The average total rainfall falling on the study area is equal to 1104.4 Mcm of water. Therefore the percentage of recharge from rainfall is:

$$\text{Areal recharge} / \text{Areal rainfall} * 100\% = 234.8 / 1104.4 * 100\% = 21.3 \%$$

The recharging quantities are distributed along a log-normal distribution with a recharging peak at April- May which lags three months from the rainfall peak that took place in December and January. These findings are consistent with the assumptions made concerning the delay effect of rainfall event to cause a change in groundwater level expressed by the lag-time period of peaks.

Conclusion and Recommendations

Monthly rainfall data when display graphically doesn't follow a consistent trend for all hydrologic years. Winter might begin early in October and increases till it reach its peak at December, while other years winter is late and the first rainfall event occurs in Dec. This variability phenomenon can be reduced if long term average monthly rainfall values are considered. The long term average monthly rainfall values are noticed to follow a specific trend which increases from Oct. till a peak is noticed at Dec.

Monthly groundwater level values followed a specific trend when plotted against time. The groundwater level is noticed to rise gradually till it reaches a peak between April and May. The groundwater level then decreases gradually till it stops three months from the peak. A comparison between long term average monthly rainfall values and monthly groundwater levels led to lag-time calculation. The lag-time was found equal to three months in this study.

The groundwater level peak usually appeared in April which is three months away from the long term average monthly rainfall peak that took place in Dec. The rise of groundwater level during the dry months from May to July confirmed the accumulation observation of any rainfall event impeding on the ground surface. The percentage of rainfall that recharged the study area is found equal to 21% of rainfall value. This percentage is a function of the geological nature of the study area that determines the degree of transmissivity of the formations. The thorough analysis of rainfall and groundwater level data revealed the direct relation between precipitating quantities and rising groundwater level.

Implications and Recommendations

This study is the first study reflecting the sub basin of the WAB. The lag time explains the continual flow of the springs in the Catchment. The results will put imprints in the discharge of the wells and their Quotas. The study is a humble attempt for developing an analytical mathematical approach for monthly estimation of recharging quantities in semi-arid to arid regions. Such studies are important for developing conceptual models for the available groundwater basin to quantify available water resources and carry sound management techniques to preserve these water resources from deterioration both in quality and quantity.

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Executive Summary

The quality of roof-top harvested rainwater which is used for domestic and drinking purposes in the middle area of the West Bank and the factors affecting it are assessed through wet season surveillance (from Nov., 2005 to April, 2006). 72 rainwater samples are collected from ferroconcrete and rock storage cisterns (48–114 m³ capacity) tested in terms of physical, chemical and biological characteristics. The results reveal that the harvested and fresh rainwater samples are alkaline with pH values above 8.

Rainwater has very low concentration of TDS of less than 68 mg/l for fresh water samples and below 136 mg/l for harvested ones. Turbidity of fresh and harvested rainwater mostly do not comply with the Palestinian standards and WHO guidelines (exceeds 5 NTU). Total and fecal coliforms are detected respectively in 100% and 86% of the tested harvested rainwater samples. Total and fecal coliforms are absent in fresh rainwater. Harvested rainwater has low concentration of ions as Ca⁺⁺, Na⁺, Cl⁻ and total hardness. Nitrate concentration in the cisterns closer than 10 m from cesspits was comparatively high. Harvested rainwater is not contaminated with heavy metals like Cr, Zn and Pb as the measured values fell within the PS41 and WHO guidelines.

The Run-Off Coefficient (ROC) is in the range of 0.70 to 0.90. To use rain water harvesting as a domestic source; systems must be well managed and disinfection or another recommended water treatment should be applied.

Introduction

Palestine is among the countries with the scarcest renewable water resources per capita due to both natural and artificial constraints. Rainwater Harvesting Systems (RWHS) are playing an important role to meet the shortage in water demand. A storage tank with the capacity to hold 70m³ can provide a good complementary supply to other available water sources for the consumption of a family with seven individuals during a period of 6 to 7. It would contribute with 50 liters per person per day, which is half of the recommended ideal per capita consumption per day (100 liters/day/person) according to Palestinian Standards. The availability of water through a cistern also liberates women and children from walking long distances to fetch water (local springs). Furthermore, access to harvested rainwater protects the family members against illnesses related to diseases through consumption of contaminated local spring's especially with high concentration of nitrates which caused blue baby disease. Nonetheless, the quality of harvested water is still inadequately unanswered question in Palestine. Rainwater collection can be thought of as involving a system whose components are identified as catchment surfaces, conveyance systems and storage tanks. Moreover, most components in this system must have associated means of protection against such hazards as contamination of water and mosquito breeding.

Approaches and Results

The study is carried out in Kubar and Abu Shekheidim villages located in Ramallah and Al Bireh District. The two villages are served with water but not sewerage networks, and use cesspits. Many of the houses have rain water cisterns and some of local springs which are used during periods of water supply interruption. A survey is conducted to select 12 households with rain water harvesting cisterns out of 65, and those who are operating, maintaining and using harvested water and interested in the survey are selected to carry out the study. Seven RWHS with two different shape storage tank and three rooftop types are selected in 2 villages to undertake the quality assessment. About 72 samples were collected and tested based on Standard Methods for examination while two rain water samples are collected directly before falling on the roofs and compared with the quality of another two samples collected from the main drinking source (Tap water-groundwater source). Five cisterns are selected to study the percentage of total rainfall that can be harvested from a particular surface, and based on water mass balance, the Runoff coefficient is calculated.

All physical parameters tested passed PS41 and WHO guidelines except for turbidity parameter for most samples. The failure in turbidity is attribute to dust in the atmosphere. The pH ranges of harvested rainwater samples are generally well within the acceptable limits. The TDS values of the samples are very good (low) which less below 136 mg/l. Heavy metals in all cisterns are comply with PS41 and WHO Standards so that the rainwater harvesting in the area of study are not contaminated with selected toxic metals like lead, chromium and zinc. Nitrate concentration in all water samples was below required by PS41 and WHO guidelines (<50 mg/l). Some of these samples show the concentration of nitrate is relatively high than others in cases of distance from cesspits less than 15 m. Samples show that low concentration (within the acceptable limits) of ions as Ca^{++} , Na^+ , Cl^- and total hardness as expected. All RWH samples have TC & FC counts more than 3 & 0/ 100 ml respectively. The sources of microbiological contamination are the human and animal waste present in the cistern catchment area especially in cisterns which closed to cesspits within 15 m like in case cisterns 6, 7, 12, and 13. Properly design and cleaning the catchments area before the rainy season starts is a must and people should be aware of that all the time. Survey also reveals that after the first rain, TC and FC count in the cisterns are high due to roof washout. The Run-off coefficient (ROC) results and analysis indicate that average potential for potable water savings range from 70% to 90% per year.

Conclusions

The results of the water quality tests can be summarized as the quality of harvested water from roof catchments meets mostly the drinking-water standards values in terms of Physical-chemical properties but not in biological while the quality of fresh rainwater is meeting the PS41 and WHO guidelines in all characteristics, the study reveals that harvested water is heavily contaminated microbiologically and the TDS values of the fresh and harvested RW samples are low if compared with ground water sources (Tap Water). Electrical conductivity of the rainwater is low and is about twice the TDS value for this source. Mostly, Turbidity values are high above 5 NTU recommended by the WHO and Palestine Standards (PS41).

The rainwater (both direct and harvested) is aerobic with DO values above 7 mg/L. RWHS is not contaminated with heavy metals like Cr, Zn and Pb. So that no problems or hazards on health when using rainwater as a domestic source. The Run-Off Coefficient (R) extends from 0.70 to 0.90 for Ferro-concrete catchment.

The rain water harvesting systems in the study area is technically feasible by decrease the pressure on ground water consumption to 74%.

The householders in the study area does not construct the cisterns correctly so that it must be needed to be sized correctly in order to give adequate storage capacity and at the same time minimize capital investment

Implications and Recommendations

- Rainwater harvesting system should be implemented on large scale in rural areas to alleviate the pressure on water resources. Appropriate treatment like disinfection of collected rainwater would be necessary to make the harvested rainwater fit for drinking.
- Some precautions should be focused on when deciding to construct and locate an underground cistern, for example building it downstream of the catchments area and upstream of possible local sources of pollution, such as cesspits and septic systems.
- Inform the public about the adverse health effects of contaminants and explains the steps people can take in their homes to reduce their exposure to pollutants in drinking water.
- To reduce the probability of coliform in rainwater harvesting systems and wells; always keep the rain catchment clean and free of debris; trim trees brushes near the area to prevent animals from entering the storage tanks.

Obstacles and Incentives of Applying Anaerobic Technologies of Sewage Treatment in the Mediterranean Region

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Executive Summary

Anaerobic technologies have been widely perceived as of low cost and the core of sustainable treatment schemes. This research aims at investigating the obstacles and incentives of applying anaerobic technologies for sewage treatment in the Mediterranean Region. Two forms of questionnaires are distributed, one for wastewater sector professionals and the other for donors. The questionnaires are distributed through email, fax, and web based platforms and by personal interview with several academic, technical and managerial persons in several Mediterranean countries and countries with Mediterranean climate (Palestine, Jordan, Greece, Italy, Turkey, Spain and Morocco). The results reveal that the major obstacle of applying anaerobic wastewater treatment technologies in the Mediterranean Region is not lack of research, knowledge about systems design or construction, but rather the experience in operation. As a general conclusion, the most important parameter to be taken into account during selection of wastewater treatment technologies is the operational cost, since 100% of both interviewed professionals and donors agreed about this point.

The physical planners, decision makers, engineers, operators, and social scientists, representatives of governmental and non-governmental organization and target groups should be informed and trained on the low cost anaerobic based wastewater treatment aspects. The roles of all of the related stakeholders in technology selection process, all in his/ her position and abilities should be distributed carefully.

Introduction

Simple, affordable, and efficient treatment systems are urgently needed in developing countries because most of the conventional technologies currently in use in industrialized nations are too expensive and complex. Among the different treatment systems now available worldwide, the anaerobic process is attracting more and more the attention of sanitary engineers and decision makers. It is being used successfully in tropical countries, and there are encouraging results from subtropical and temperate regions.

Conventional mechanical treatment facilities in developing countries have had a sparse record of success. They frequently do not function as expected because of a variety of technical, financial, and institutional reasons. Alternative treatment technologies emphasize cost reduction, integrated system management, minimal mechanical operations, water reclamation and nutrient conversion wherever feasible. Technologies include simplified, lower cost wastewater collection infrastructure, anaerobic enhanced primary treatment and lagoon-based post-treatment processes that can achieve high effluent quality levels and that can be managed adequately by non-specialists. The application of these expensive systems does not offer a sustainable solution for sewage treatment in less wealthy countries like Palestine. On the other hand, anaerobic treatment has been proven to be an admirable process and considered by many authors as the core of sustainable waste management. Combined with a proper post-treatment, anaerobic treatment provides a sustainable and appropriate method for providing a good quality effluent from domestic sewage, not only for developing countries but also for advanced countries. It is being used successfully in tropical countries, and there are some encouraging results from subtropical and temperate regions. Even though, conventional sole aerobic based treatment technologies are still dominant and introduced in the new wastewater treatment projects in the whole Mediterranean region.

This research is aiming at investigating the obstacles and incentives of applying anaerobic technologies of sewage treatment in several Mediterranean countries or countries with Mediterranean climate (Palestine, Jordan, Greece, Italy, Turkey, Spain and Morocco). The idea of this work is to investigate why up till this moment anaerobic wastewater treatment is not integrated in many recent wastewater treatment projects.

Approaches and Results

The objectives of the study are attained mainly by surveying by the means of distributing questionnaires, via email and fax, among many academic, technical and managerial people in the whole Mediterranean countries on which basis they choose the treatment technologies, and why anaerobic treatment technologies are chosen or not chosen! And also, investigate the roles of both private and public sectors in addition to academic establishments and development assistance agencies (USAID, KFW, UNDP, GTZ and PECDAR).

The lack in the operational experiences has resulted in lack in confidence in the anaerobic systems application, and so practice engineers are reluctant in taking the risk of trying. The majority of the professionals (54.3%) believe that the served communities do not play an important role in selecting the wastewater treatment technologies and schemes and the majority of professionals (52.9%) and donors (83.3%) stated that the academic establishments have no role in the decision making process. The role of aid agencies and donors in selecting the wastewater treatment technologies, as they believe, can be described almost equally as recommendation (35.3%), imposition (29.4%) and participation (26.5%). This indicates that donors do not all have the same policy. Also, 50% of the interviewed donors affirmed that they choose technologies in which the engineers in their countries are familiar with. The most important parameter to be taken into account during selection of wastewater treatment technologies is the operational cost, since 100% of both interviewed professionals and donors agreed about this point.

Conclusions

- Anaerobic wastewater treatment systems are more sustainable with low operational and maintenance cost.
- In the Mediterranean Region there is enough experience in anaerobic treatment in research, design and construction, and there is no enough experience in operation.
- The interested stakeholders are mostly not involved in the selection and implementation processes, therefore, the operation and maintenance costs will be a major concern.
- The most important obstacle is that anaerobic wastewater treatment is not inte-

grated in many recent wastewater treatment projects and this is due to mainly two reasons that are practice engineers lack confidence in the system, and so they do not want to take the risk of trying and practice engineers are not fully aware and need more training and education.

Since 36.5% of professionals and 66.7% of donors, which is the majority, agree about these points that are since operational cost has the highest weight (8.23 of 10) related to the priority of wastewater treatment technology selection parameters in the region according to believe of professionals and land availability has the highest weight according to the governments (7.45 of 10). Mostly, the academic establishments have no role in decision making in wastewater treatment technology selection since 52.9% of professionals and 83.3% of donors agree about this point. This may lead to a wrong selection and may slower the implementation stages of the project. Since percentages of types of role played by aid agencies and donors in the selection of wastewater treatment technology are near to each other (recommendation 35.3%, imposition 29.4% and participation 26.5%), this indicates that donors do not all have the same policy, but the general belief is that most try to recommend what donors think is the appropriate solution.

Implications and Recommendations

The roles in decision making in the wastewater treatment technology selection should be distributed carefully to the related stakeholders, all in his position and abilities. Alternative options have to be examined with the involvement of all of the stakeholders.

It becomes very important to train physical planners, decision makers, engineers, social scientists, representatives of non-government organization and target groups so that proper decisions can be done about proposed designs for treatment plants to be constructed in the near future.

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Drivers and Barriers of House Onsite Grey Water Treatment and Reuse in Palestinian Rural Areas

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Executive Summary

Wastewater management in Palestinian rural communities is highly neglected, where they still depend on cesspits. In the last fifteen years, house onsite wastewater management systems have been blooming over the West Bank in rural areas. Some of these projects were not successful, and there is a waste of funds and efforts, but some others are still operational very successfully. The aim of this research is to assess the impacts and social acceptance of onsite GWTPs on the environment, health, society (from beneficiaries' perception), to find out the drivers and barriers of implementing GWTPs, success and failure lessons. Applied methodology consisted of two parts, two workshops and two questionnaires, the first questionnaire targeted the households served with GWTPs, and the other one targeted the owners of cesspits. The results reveal that reuse of treated grey water in irrigation was the main incentive for applying GWTPs, follow by saving of cesspit discharge frequency and it's financial. The findings show that 13% of the total constructed treatment plants are not operated. The most important barrier is odour emission and insect's infestation. 25.1% of the implementing agency never monitor or check the treatment plants, and 59.3% of them monitor and check the plants only at the first 2-3 months, follow by inadequate beneficiaries' experience in operation and maintenance. A health concern of crop quality irrigated by treated grey water is another barrier as well. House onsite grey water management systems is a promising and acceptable in rural communities, but barriers should be alleviated.

Introduction

Palestine is among the countries with the scarcest renewable water resources per capita due to both natural and artificial constraints, amounting to around 70 cubic meters per capita per year for all purposes (PWA, 2009). In reference to sewage networks, they have been absent from every agenda and have not been developed. They also lack operational plans linked with a clear strategic vision need for development. The development of the wastewater treatment systems in Palestine has not exceeded the establishment of a few main projects, such as the water treatment plants in Northern Gaza, Gaza City and Al Bireh in addition to a few minor projects executed by civil organizations (even though they lack a strategic vision). In the last fifteen years, house onsite grey water management systems are blooming over all the West Bank in the rural communities, justified by lack of adequate wastewater services and driven by the business opportunity for the supporting NGOs funded by donors. Some of those projects were not successful, but some others are still operational very successfully. The drivers and barriers of providing onsite grey water treatment plants from beneficiaries' view are not reasons of implementing such management in the rural communities, as these reasons are not investigated to assess these systems.

Approaches and Results

Applied methodology consist of two parts, two workshops (Inception Workshop and Professional Workshop) and two questionnaires, the first questionnaire target the households served with GWTPs, and the other one target the owners of cesspits. For the purpose of questionnaire building two workshops are conducted to find out the main issues and significant aspects for the target beneficiaries. Prior to questionnaires building, an inception workshop is arranged to gather the owners of GWTPs and cesspits' users to reveal the concerns, opinions, views of the local community about their sanitation systems. The professional workshop targets the key persons who work in water and sanitation sectors. 185 questionnaires are distributed for GWTPs beneficiaries' at household level in 18 communities in the West Bank, and 485 questionnaires are distributed for Cesspit's owner questionnaires at household level in 19 communities in the rural areas in the West Bank.

Reuse of treated grey water in irrigation is the main incentive for applying GWTPs as stated by 88.0% of beneficiaries. The second incentive is the saving of cesspit discharge frequency and its financial consequences as stated by 71.3%. 72.5% of the

beneficiaries stated that they have a water shortage before providing GWTPs; and the GWTPs contribute to solve it. Availability of fund is an important driver, as stated of 70.7% of the interviewers. Education level has an impact on GWTPs acceptance, 73% of not educated beneficiaries are satisfied, and (58.8%) of educated people. Islamic religion considered a driver; as the majority of people (70%) accept reuse of treated grey water in irrigation. The majority of GWTP's beneficiaries (70.4%) are satisfied of GWTPs. The findings show that 13% of the total constructed treatment plants are not operated. The most important barrier as mentioned by 66.5% is odour emission and insect's infestation. 25.1% of the implementing agency never monitor or check the treatment plants, and 59.3% of them monitor and check the plants only at the first 2-3 months, followed by inadequate beneficiaries' experience in operation and maintenance. A health concern of crop quality irrigated by treated grey water is another barrier as well. The results show that the average number for emptying the cesspit per year before construction of onsite GWTP is 6.9, where the people pay 6% out of their monthly income on cesspit's emptying, which decreased to 4.1 after providing onsite GWTPs. 55.4% of the interviewers accept construction of onsite GWTPs supported by external funding. The majority of people (74.8%) prefer sewerage networks for wastewater management, 15.5% of people prefer onsite GWTPs, and 9.5% prefer cesspits.

Conclusions

Drivers of applying GWTPs that is reuse of treated grey water in irrigation is the main incentive for applying GWTPs as stated by 88.0%, reduction of cesspit discharge frequency and its financial consequences as stated by 71.3%, Availability of fund is an important driver for construction of GWTPs as stated by 70.7.

Barriers of applying onsite GWTPs that are the first barrier as mentioned by 66.5% is odour emission and insect's infestation. 59.3% stated that the systems lack follow up from implementing agency side. The system failures are also caused by inadequate beneficiaries' experience in operation and maintenance. Health concerns and doubt of the crop quality irrigated by treated grey water is another barrier.

Implications and Recommendations

- There is an essential need to improve the performance of the treatment plants and to rise up the treatment efficiency, and to introduce well-operated wastewater treatment facilities.
- At the policy level, the government should encourage and be more aware

for potential applying of onsite GWTPs in rural communities, so the government should be more involved in wastewater management in rural areas to replace cesspits.

- Implementing agency should make regular monitoring and maintenance of the onsite GWTPs, especially after the end of implementation and consider this phase as a part of the project implementation,
- GWTPs beneficiaries require needed training of operation and maintenance on the system management to maintain sustainability and to handle system successfully.
- Develop the public awareness programs, to better understanding and improve public knowledge of wastewater systems and perception toward reuse schemes, in parallel with field visits of local people to other wastewater treatment and reuse for sharing knowledge and ideas.
- A more proper system is required to handle the wastewater and replace cesspits and its implications on environment, ground water and health in rural communities.

Characterization of Household Wastewater Streams as a Tool for Pollution Control

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Executive Summary

On-site sanitation concepts have not been adequately explored in Palestine, where domestic wastewater is characterized by high strength and seasonal temperature fluctuation. The main objective of this research is to increase the knowledge on the quantity and quality of the various household wastewater streams, to enable design and development of sustainable decentralized wastewater management concepts.

Household wastewater sub-streams of five houses are separated and characterized in terms of quantity and quality. The results reveal that domestic wastewater of the five studied houses (H1, H2, H3, H4 and H5) are of high strength due to high concentration of pollutants like COD, BOD, phosphorous, ammonia and Fecal coliform. Toilet and kitchen sink wastewater streams are the main sources of pollution. The average specific wastewater is 32.5(1) l/c.d; While the average water that is provide about 48.4(3.5) l/c.d. Approximately 24.8(1.6) l/c.d from grey wastewater, i.e. wastewater from hand basin, kitchen sink and in the shower. The grey wastewater represents the major part of domestic sewage (60-70%) and remaining 7.7(1.4) l/c.d is from toilet wastewater.

The BOD concentrations are in the range of 652-915 with average value of 809(103) mg/l which corresponds to 73.2(8.9) g/c.d. This rather high specific BOD₅ value indicates the cultural influence. Based on the overall results of this research, separation at source of grey and black water, and house onsite or community on site grey water treatment and reuse is highly recommended.

Introduction

The need for adequate treatment of domestic wastewater is self evident in Palestine particularly for small rural communities, in which about 60% of the total populations in Palestine are living. Knowledge about wastewater characteristics is necessary for design and operation of treatment facilities and to determine the sequence of treatment systems. Detailed characterization data regarding these flows are necessary not only to facilitate the effective design of wastewater treatment and disposal systems, but also to enable the development and application of water conservation system and for waste load reduction strategies. Mahmoud et al.

(2003) showed that the specific waste production for Ramallah and Al-Bireh cities in terms of COD, N and P are much higher than those the household waste production, source and composition for some countries (Germany, Denmark and Sweden) and Holland. They argued that the high COD content of wastewater in Palestine and other countries in the Middle East, like Jordan, is not only due to low water consumption, but also due to people's habits. In Palestine, separation of household wastewater into black wastewater and grey wastewater is an emerging process. Therefore, knowledge about the quantity and quality of the various household wastewater sub streams is vital for innovative collection and treatment systems that maximize the possibility of onsite collection, treatment and reuse. The specific objective of this research is to increase the knowledge on the quantity and quality of the various household wastewater streams in order to enable formulating innovative concepts which lead to maximizing reduction of the net water use by reusing treated effluent water.

Approaches and Results

Five Palestinian houses, four in Anata village and one in Hizzma village, were chosen for conduction of this research. The sanitary sewers in the five houses are separated to enable the quantification and characterization of each household wastewater sub streams, namely toilet, hand basin, kitchen sinks, shower and wastewater from washing clothes. The wastewater composition and flows are monitored for a total period of six months covering both winter and spring periods. The separated wastewater streams are collected over 24 hours. The volume of flow rate variation dictates the time interval for sampling; however, on the average every two hours a sample have been taken and the flow volume was measured.

The results obtained reveal that domestic wastewater of the five studied houses (H1,

H2, H3, H4 and H5) are of high strength classified as a strong domestic type due to high concentration of pollutants like COD, BOD, phosphorous, ammonia and Fecal coliform. Toilet and kitchen sink wastewater are the main sources of pollution. The wastewaters at community level in the research area have a typical domestic sewage of COD/BOD₅ ratio of 2.23 (STD (0.14)). The specific production of COD_{tot} is about 1802(316.7) mg/l which represents about 162.1(21.6) g/c.d. Where, the COD specific production for H1, H2, H3, H4, and H5 are 166.1(14.9), 182.5(29.1), 178.6(13.6), 154.6(32) and 128.8(17.6) g/c.d, respectively. The results also reveal that the main fraction of COD in the raw sewage is particulate (suspended and colloidal), which represented 71.7% of the total COD. The percentage of the COD_{dis} was 28.2%. In addition to COD, the wastewater characteristics at community level in the research area show that BOD values are somewhat in the range of 652-915 with average value of 809(103) mg/l which represents 73.2(8.9) g/c.d. BOD₅ specific production for H1, H2, H3, H4 and H5 are 81.4(5.7) g/c.d, 80.6(9) g/c.d, 76.2(7) g/c.d, 66.2(9.3) g/c.d and 61.4(6.5) g/c.d, respectively. The wastewater characteristics at community level in the research area show that VFA with average value of 214(35.1) mg/l which represents 7(1.1) g/c.d.

The average of wastewater is 32.5(1) l/c.d; While the average water that is provide about 48.4(3.5) l/c.d. Approximately 24.8(1.6) l/c.d from grey wastewater, i.e. wastewater from hand basin, kitchen sink and in the shower. The grey wastewater represents the major part of domestic sewage (60-70%) and remaining 7.7(1.4) l/c.d is from toilet wastewater.

Conclusions

Raw sewage is of high strength, with a COD_{tot} concentration of 1802(316.7) mg/L about 162.1(21.6) g/c.d, and a high percentage of COD_{sus} (64.9%) around 1167(191.6) mg/L about 105(11.9) g/c.d. Toilet and kitchen sink wastewaters are the highest contributions of COD in domestic wastewater which about 59.5(16.8) g/c.d and 84.9(22.5) g/c.d, respectively.

The main source of NH₄⁺-N in domestic wastewater is feces and urine. The specific production of ammonia in five houses is about 105.4(29.4) mg/l. From toilet alone 92.7(27.1) mg/l. Kitchen sink can be another source of ammonia that's come from using detergent and soaps; food waste causes some ammonia in wastewater.

Biological oxygen demand (BOD₅) is somewhat in range 652-915 mg/l for sewage

wastewater. For wastewater from toilet are between 187-422 mg/l. COD /BOD₅ ratios found in our study for the effluent wastewater from houses as an average 2.23(. However, since the ratio is close to the upper bound of 2.23 (0.14). Each person produces about 32.5(1.5) l/d of wastewater; where the average water consumption are 48.4(3.5) l/c.d the remained volume of water used in other objectives. Wastewater produce from toilet are about 7.7(1.4) l/d (faeces and urine using large water for flushing). Grey water represents the major part of domestic sewage 75.7%.

Implications and Recommendations

- It is recommended to separate black wastewater from grey wastewater in household wastewater in order to reduce the volume of pollution in sewerage. Furthermore, toilet wastewater rich in fecal coliform, so, it's dangerous on human health.
- Use of grey wastewater for urinal and toilet flushing is one of the possibilities since the water that is used for toilet flushing in many countries today is of drinking water quality. It should be possible in the future to have a dual water system in households with two water quantities. The first a high quantity drinking water originating primarily from natural water resources, and a second water quality for all other uses. This should bring with it an environmental relief on both the water and energy sectors.



Health Risks Associated With Consumption of Untreated Household Roof-Catchment Systems

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Executive Summary

Rain harvesting is becoming more common in the Palestine as a result of drinking water scarcity. Although it might pose serious human health risk, this water is being consumed without treatment in many areas of the West Bank. The present study evaluates the physicochemical and microbial quality of harvested rainwater that is used as potable water in the West Bank. Samples from roof-harvested rainwater storage tanks (n=42) are collected in summer/2006-winter/2007. Physicochemical parameters measured are: temperature, pH, electrical conductivity, salinity, total dissolved solids, turbidity, nitrate, copper and lead. With few exceptions, all these parameters are within WHO guideline values. All samples (100%) are found to contain coliforms and to be heavily contaminated with heterotrophic bacteria. About 67% of all samples are contaminated with fecal coliforms. Specific PCR technique confirmed the presence of five pathogenic microorganisms that can be ordered according to their prevalence as: *Citrobacter*(83%)>*Acinetobacter* (78%)>*Aeromonas* (52%)>*Pseudomonas* and *Campylobacter* (7%).

Prevalence of microorganisms in summer samples is higher than in winter samples. Although the physicochemical quality of most harvested rainwater samples is in accordance with WHO guidelines for drinking water, stored rainwater is significantly contaminated with bacteria resulting in significant human health risk from infectious diseases.

Introduction

The depletion of groundwater sources, poor quality of some ground and surface waters, high tap fees for isolated properties, flexibility of rainwater harvesting systems, and modern methods of treatment provide excellent reasons to harvest rainwater for domestic use. However, because water is a universal solvent, it absorbs all kinds of contaminants on its travels to the reservoir, in addition to pathogenic organisms. While in residence in the reservoir, harvested water can come in contact with more contaminants.

Therefore, this study aims at evaluating health risks associated with the consumption of untreated rainwater harvested in the West Bank of Palestine through roof catchment systems. The study analyses the physicochemical and microbial quality of the harvested rainwater.

The results of the study indicate that the physical and chemical properties of harvested rainwater are generally within the WHO guideline values; indicating good water quality for drinking purposes. However, the microbial quality of the harvested rainwater is poor and poses health risks if consumed without pre-treatment.

Approaches and Results

Harvested rainwater samples are collected in summer and winter 2006/2007 from storage tanks in different locations in the West Bank, Palestine. In situ, temperature, pH, turbidity, Total dissolved solids (TDS), electrical conductivity (EC) and salinity levels in harvested rainwater are measured using portable equipment from HACH Company, Loveland, CO, USA. In the laboratory, nitrate levels are measured using a capillary ion analyzer (Millipore Water Instruments, USA) and levels of copper and lead are measured using A Analyst 600 atomic absorption spectrophotometer (Perkin Elmer, USA). Total coliform (TC), fecal coliform (FC) and heterotrophic plate count (HPC) were determined in all rainwater samples by the membrane filtration technique as described in Standard Methods for the Examination of water and wastewater. The presence of six pathogenic (*Campylobacter*, *STEX E. coli*, *Helicobacter pylori*, *Legionella*, *Shigella* and *Salmonella*) and five opportunistic (*Citrobacter*, *Acinetobacter*, *Aeromonas*, *Pseudomonas aeruginosa* and *Mycobacterium*) bacteria in harvested rainwater samples is tested using specific polymerase chain reaction (PCR) after DNA extraction.

The pH values for all rainwater samples collected in summer are within the basic range 7.4–9.9. In winter, 38% of the samples have acidic pH values. The pH values of 28% of the samples are not within the WHO guideline range set for drinking water of 6.5–9.5. Mean EC value for summer samples (286.4 $\mu\text{S}/\text{cm}$) is less than that found in winter samples (378.5 $\mu\text{S}/\text{cm}$). These values are much less than the EC value for tap water in the West Bank, reported as 760 $\mu\text{S}/\text{cm}$. Salinity mean values for rainwater samples are generally low (all samples' average is 0.16‰). Rainwater salinity is clearly lower than tap water salinity found in the West Bank, typically 0.4‰. All TDS values measured for rainwater samples are well below the WHO guideline value of 1,000 mg/L. The mean TDS value for all samples is 157.5 mg/L with winter samples having higher TDS values than summer ones. Turbidity measurements in rainwater samples are well below the guideline value set by WHO of 5. Out of 42 harvested rainwater samples analyzed, only one sample exceeded the WHO guideline value. The mean turbidity of all samples is 0.85 NTU. Rainwater turbidity values seem to be lower than those found in tap water samples from the West Bank at 1.72 NTU. Nitrate mean level in the harvested rainwater samples was 3.06 mg/L with the highest value recorded as 5.8 mg/L. Nitrate levels are well below the guideline value of 50 mg/L set by WHO. Concentrations of copper in harvested rainwater samples are below 200 $\mu\text{g}/\text{L}$ of the WHO guideline value. The highest Cu concentration recorded is 54.35 $\mu\text{g}/\text{L}$ during the summer period from a reservoir. Rainwater from two reservoirs is found to have Pb concentrations that exceed 10 $\mu\text{g}/\text{L}$ of the WHO guideline value. The highest value recorded (30.67 $\mu\text{g}/\text{L}$) is during the winter period.

All harvested rainwater samples are found to be contaminated with TCs. The number of colonies/100 mL ranged between 2 and >1,000. Winter samples are found to contain higher numbers of TC colonies than summer ones. About half the WS (10/21) are found to contain more than 1,000 CFU/100 mL whereas, only 2/21 summer samples had TC counts that exceeded 1,000 CFU/100 mL. FC bacteria are detected in about 71% of summer samples, 62% of winter samples and in 66.7% of all samples although all rainwater samples analyzed are negative for STEC E. coli. Thus, most of the harvested rainwater samples are not in accordance with the WHO guideline value of 0 CFU FC/100 mL in any water intended to be used for drinking purposes. All harvested rainwater samples are heavily contaminated with HPC microorganisms.

Out of 11 bacterial species tested by molecular biology techniques (specific PCR), the presence of five species in harvested rainwater is confirmed. *Citrobacter* is the

most common in harvested rainwater samples (100% of summer samples), while the least common are *Pseudomonas* and *Campylobacter* (10% of summer samples). The results indicate more bacterial prevalence in summer samples than in winter ones. Many pathogenic bacteria such as; *Shigella*, *Salmonella* and *STEX E. coli* were absent in all samples.

Conclusions

The physicochemical quality of roof-harvested rainwater in Palestine is generally good enough for it to be used as drinking water. However, the microbial analysis of stored rainwater samples indicated significant microbial contamination with TC and FC, HPC and some other bacteria. Generally, summer samples are found to be more contaminated with microbes than winter ones. The presence of these pathogens/potential pathogens indicates clearly that this water is not suitable for direct consumption without treatment.

Implications and Recommendations

Reducing health risks posed by microbes in stored water requires some actions to be taken before filling the storage tanks and during the storage period. These measures include keeping animals away from the roof and cleaning up bird droppings, diverting the first flush out of the storage tank and regularly cleaning and disinfecting the storage tank and stored water. This is important to prevent the formation of biofilms in the storage tank. Finally, the opening of the storage tank should be kept properly closed to minimize microbial contamination during storage and keep the stored water in good microbial quality.



Pollution and Water Quality Assessment of Wadi Al- Qilt

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Executive Summary

Pollution and limited access to available water resources are some of the major challenges facing the Palestinians in the West Bank and Gaza Strip. Arid to semiarid conditions, overexploitation, mismanagement of water resources and being shared with regional countries caused complex but intrinsically inter-related problems of supply, demand, ownership and water quality. The Jericho Water Treatment Plant (JWTP) is providing drinking water for almost 5,000 inhabitants living in Aqbat-Jabr refugee camp. Recent studies revealed microbial and chemical pollution of the main canal feeding JWTP especially during winter season. As a natural resource and basic element of Palestinian environmental resources, decisions affecting upgrading the current water treatment plant and the quality of the feeding inlet should be based on proven scientific understanding. The study is conducted to provide information about Al Qilt drainage basin including types and possible sources of pollutants.

The system is composed of two major tributaries; Fara and Sweanit that form the main stream. Wadi Al Qilt is formed after the combination of the tributaries with the discharge from Ein Al Fawwar and Ein Al Qilt springs. In order to assess the water quality of Wadi Al Qilt drainage basin, sampling stations are assigned along the path of the wadis starting from Al-Bireh Wastewater Treatment Plant (AWWTP) to JWTP inlet, and samples from the five springs are analyzed to determine their quality as well. Chemical, physical, biological and hydrobiological studies are conducted between November (2004) and July (2005) in Wadi Al Qilt drainage basin.

Results revealed major trends for most of the measured parameters; decreasing the concentration of various parameters as going from AWWTP to the open transportation canal where the factor behind that is the dilution process resulted from springs' discharge that ends up in the wadis forming Wadi Al Qalit. Results showed higher concentrations of lead and cadmium than allowable for drinking water in three spring samples, whereas, five samples out of ten are contaminated with fecal coliform, which indicate the presence of pollution sources in the recharge area. While results showed three samples from wadis are contaminated with aluminum, cadmium and lead, and all samples are microbial contaminated.

Introduction

Pollution and limited access to available water resources are some of the major challenges facing the Palestinians in the West Bank and Gaza Strip. Arid to semiarid conditions, overexploitation, mismanagement of water resources and being shared with regional countries caused complex but intrinsically inter-related problems of supply, demand ownership and water quality.

Previous studies reported on obstacles for pollution cut from urban Palestinian towns, where erection of urban sewage works are the first priority of the Palestinian Water Authority Policy, as the pollution load has been reduced up to 75 and 95% in organic pollutants (TKN and BOD₅ respectively) by Al Bireh wastewater treatment plant (AWWTP), launched in February 2000. The drainage basin of Wadi Al Qalit is chosen for the present study, as there is a lack of data concerning the impact of AWWTP effluent on the self-purification capacity of the season receiving water body (Wadi Al Qalit). Secondly, evidence of pollution from many springs in this basin as well as the sewage flow along the Wadi is a significant health hazard for the local inhabitants and users downstream. Jericho Water Treatment Plant (JWTP) provides drinking water for almost 5,000 capita living in Aqbat-Jabr refugee camp. Recent studies revealed microbial and chemical pollution of the main canal feeding JWTP especially during winter season. As a natural resource and basic element of Palestinian environmental resources, decisions affecting upgrading the current water treatment plant and the quality of the feeding inlet should be based on proven scientific understanding.

This research study is conducted to provide information about Al Qilt drainage basin including types and possible sources of pollutants. The main objective is to investi-

gate the impact of treated effluent from Al-Bireh sewage works on Wadi Al Ein and identify other potential pollution sources within Al Qalit drainage basin.

Approaches and Results

Personal interviews and technical site visits are made to assign sampling stations and collect data on the potential sources of illicit industrial discharges and waste within the watershed area of Wadi Al Qalit basin. The drainage basin is composed of two major tributaries; Fara and Sweanit that form the main stream. Wadi Al Qalit is formed after the combination of the tributaries with the discharge from Ein Al Fawwar and Ein Al Qilt springs. In order to assess the water quality of Wadi Al Qalit drainage basin, sampling stations are assigned along the path of the wadis starting from Al-Bireh Wastewater Treatment Plant (AWWTP) to JWTP inlet, and samples from the five springs are analyzed to determine their quality as well. In addition to the inlet of JWTP sampling station, twelve sampling stations are assigned along the two wadis, starting from AWWTP effluent through Wadi Al-Fawwar and the open canal feeding JWTP. Fifty six water samples from the wadis are collected and analyzed. Physico-chemical, biological and hydrobiological water analysis conducted between November (2004) and July (2005) in Wadi Al Qalit drainage basin.

Results revealed major trends for most of the measured parameters; decreasing the concentration of various parameters as going from AWWTP to the open transportation canal where the factor behind that is the dilution process resulted from springs' discharge that ends up in the wadis forming Wadi Al Qalit. Results showed higher concentrations of lead and cadmium than allowable for drinking water in three spring samples, whereas, five samples out of ten are contaminated with fecal coliform, which indicate the presence of pollution sources in the recharge area. While results showed three samples from wadis are contaminated with aluminum, cadmium and lead, and all samples are microbial contaminated.

Conclusions

The results obtained for physical, chemical and biological parameters showed that the most polluted section through Wadi Al-Qalit is the part between A WWTP and Wadi Sweanit, indicating pollution of water discharging from springs downstream. Moreover, three springs located in the drainage basin are contaminated with heavy metals, whereas two springs are biologically contaminated. Based on the geological

nature of the study area, these springs are directly recharged through fractures and fissures characterizing limestone, so the infiltration of wastewater and other pollutants disposed in the drainage basin will accelerate the deterioration of their quality. According to the field visits made, several sources of pollution may affect water quality downstream such as A WWTP effluent, discharge of wastewater from some Israeli settlements at certain time, stone crushing, human and agricultural activities around Ein Al-Qilt.

Implications and Recommendations

The following implications and recommendations can be made: Revitalization and maintenance of the open channel between Ein Al Fawwar and Ein Al Qalit is a priority. As Ein Al Fawwar has good water quality and quantity this channel should be connected with the open flow canal feeding the JWTP. AWWTP effluent must be reclaimed further to reach an effluent quality to reduce the organic and inorganic materials and should be diverted before reaching Wadi Sweanit. Watershed management plan should be developed to reduce water pollution loads of uncontrolled waste disposal sites, rural cesspools and stormwater runoff events. The open canal feeding the JWTP should be covered to prevent external pollution and reduce algal growth on the sand filters of JWTP. The performance and efficacy of AWWTP should be monitored to ensure effective biological nutrient removal, thus reducing N&P inputs.

Environmental Flow Regime for Wadi Zomar

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Executive Summary

The Zomar stream has been suffering for over 50 years from a variety of domestic, agriculture and industrial pollution sources together with development pressures in the open spaces that surrounded the stream. The aim of this study is to assess the physiochemical and microbiological quality of the Wadi Zomar through one-year long monitoring, in order to assess the key factors and variables that play role in the environmental flow regime of the Wadi.

In the base flow conditions, the amount of pollutant load varied temporally according to the amount of load from point sources along the Wadi, and spatially with distance from the same sources. Significant variation is observed in response to the hydrological behavior of the catchment.

The data show that commonly the bacterial community in the Wadi is affected by two factors; the first is the cumulative factor from the beginning of the winter season, where the bacterial potential to re-enhancing its growth is limited with more rain events along the hydrological year. The second is flow event dilution where the maximum bacterial removal is noticed at the maximum flood within one flow event.

Higher flows and more frequent washout of bacteria led to lower bacterial concentrations. All three sites, Deir Sharaf, Anbta and Tulkarem during discharge event showing Fecal Coliform log removal of 3.9,7.2 1.0 respectively.

Introduction

Environmental flow have been increasingly recognized as a central issue in sustainable water resources management. It requires that a certain amount of water to be purposefully left in or released into an aquatic ecosystem to maintain a condition that will support its direct and indirect use values and related to the degree of “environmental health” we wish to maintain in the basin ecosystems. This research has introduced the main factors that control the relation between the hydraulic parameters and ecological life that maintain a healthy ecosystem. These factors and mechanism of flow with respect to different kind of biota are based on bacterial content as indicators. The presence of pathogens in one hand indicate the deterioration of life surrounded the Wadi, in other hand the presence of common flora and Coliform in considerable quantities helps the system to reduce the organic pollution and restore its organic quality. Such balance required special hydraulic conditions that should maintain a balance relation between different kinds of biota to support a healthy system.

Approaches and Results

All physiochemical parameters (pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), NH₄-N and PO₄-P) vary according to the hydraulic status of the Wadi, at dry season since most of the stream content is wastewater, previous conditions support the growth of several types of bacterial species mainly pathogens along the stream. While in wet conditions these parameters promote alkaline favor species to be more dominant. Spatially, the relatively high susceptible point for anthropogenic activity is found near Deir Sharaf point in the upper part and the low susceptible point values is found near Anbta point, with less human activities.

The above results reflect the potential of system restore under normal conditions with low pollution load and enough dilution from natural runoff which lead to high self-purification capacity along the stream path. Regular rain events enhance what is “cumulative effect” that limited the bacterial growth with time, means that even if concentration is lower, the overall load might be higher. Bacterial communities decrease after each rain events because nutrients and colonies wash out, the bacteria lost the ability to re-build its communities again due to short draught period where the second rain event make further flush out and so on.

Four pathogens species are isolated out of the samples. These are E.Coli, Klebsiella,

Enterococcus, and Pseudomonas. In general for the mid-stream samples, pathogens show decrease with rainfall events in all location except in Deir Sharaf because of nearby wastewater discharge point, where the settled and running samples show increase in all location. The results show increasing in survival E.Coli and to a lesser extent Klebsiella as wastewater discharge increase while the density of E.Coli declined immediately after each rain event. E. coli and Enterococcus densities are more strongly correlated to cumulative rainfall variables than the other microbiological indicators.

Overall, seasonal variation in the rates and types of fecal inputs, environmental conditions that impudence the persistence of enteric bacteria and hydrological conditions that enhance the transport potential of enteric pathogens within the landscape are factors that may be contributing to the seasonality in outbreaks of enteric disease in semi arid climates. The results shown above indicate the importance of sustainable good quality flow to remove the pathogens, and to keep the whole system healthy. Anabta point represents the model for good capacity in self purification and pathogens removal, where the optimal conditions with less additional pollutants are present.

Conclusions

The presence of such good quality base flow, can help in continuous nutrients and bacterial wash out, this cannot necessarily remove the whole pathogens and pollution totally, but can reduce and help in efficient removal that can reach its maximum conditions with storm water in the water time, leading finally to a good improvement on the stream water quality and consequently healthy environment in the surround. The study suggests that the restoration process is controlled in general by two main factors that mainly depend on the presence of sufficient base flow. Those are: the role of sufficient flow in preventing the presence of bacterial rich environment, and the role of flood inundation frequency in keeping system balance all over the hydrological year by increasing the number of bacterial and nutrients flush out by flood inundation.

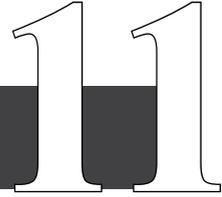
Implications and Recommendations

- Create a sustainable source for good quality runoff water all over the year, that can keep the base flow with low pollution amount and healthy eco-system that has the ability of self restoration.
- Establishing a surface flow model depending on the data obtained from this

study, to visualize the role of the two mitigation parameters in the restoration process, and to suggest the best required water amount and quality to sustain a healthy flow.

- Stopping the discharge of additional waste along the stream path, as the study shows its importance in complicating the problem of retarding self restoration along the stream.
- Constructing water treatment plants as alternative to provide and keep a good quality base flow in dry season that can support healthy environment as mentioned in the results.
- Increasing the public awareness of the issue of water scarcity, stream restoration, and pollution sources and supporting a wide range of life with healthy environment. Stakeholders should be raised to ensure public contribution in Zomar restoration.

Hazardous Waste Management in the West Bank and Gaza Strip



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Executive Summary

The here presented research aims at studying Hazardous Waste Management (HWM) practices including Healthcare Waste Management (HCWM) in the West Bank and Gaza Strip. Literature is collected and analyzed to identify the extent of the problem and its related issues. Many expert meetings are held as well as field visits. Comparative analysis of Palestinian and regional HW legislations and management practices are performed. The regional experiences in HWM are revised and it is found that the Egyptian experience could be benefited from the most in the region. The proposed management systems, including new approaches for collection, separation, storage, transportation, treatments and disposal of HWM and HCWM, that will minimize health and environmental risks as well as they will minimize associated costs. These proposed systems will deal with at least 2500 tons/year of clearly identified hazardous waste as well as an additional 354 tons/year of hazardous healthcare waste. The study recommend developing appropriate regulations, finding financial resources, promoting more cooperation between various stakeholders, waste separation at source, establishing of small centralized hazardous waste treatment and disposal facility, and on-site pre-treatment.

Introduction

The dilemma of Hazardous Wastes Management (HWM) has been recognized seriously worldwide. Although the majority of the Arab countries have already ratified the Basel Convention (BC), they are yet to set up practical mechanisms for addressing

problems caused by the generation and management of hazardous waste. The national legislations established in accordance with BC are still impeded by the severe shortage in infrastructures suitable for HWM, as well as the deficit in trained personnel to tackle the various aspects of the problem. There are many environmental problems in the West Bank and Gaza Strip, but the Hazardous and Healthcare waste is an obvious one. Until now there is no accurate information regarding the quantities generated, and no inventory is done in this field. There are a number of local industries, such as tanning, electroplating, paint, healthcare...etc, that produces HW. So far there is no clear system for managing HW neither by the specific industries nor by relevant governmental bodies.

The main objectives of the study are: (1) to study, analyze and recommend suitable HW management practices in WB and GS, and (2) to present a case study of Healthcare Waste Management in the WB and GS.

Approaches and Result

To achieve the above mentioned objectives, the methodology has been adopted by critical literature Review that is available literature and legislation resources are collected and studied to identify the extent of the problem and related issues. Regional data from neighbouring countries are also reviewed. Moreover, diagnosis of the status of HW management in Palestine which has many visits and experts meetings are held as well as field visits to the institutions concerned with HW management and to various industries and landfills to diagnose the problem of HW management. Also, identify polluting industries in the WB and GS.

And also, Selecting an Appropriate Hazardous Waste Management System that is various proper steps and processes in the management of hazardous waste are presented and explained, from generation through separation, storage, transportation, treatment, recovery to disposal.

Finally, Healthcare Waste Management Case Study that is in West Bank and Gaza Strip. Many visits and experts meetings are held as well as field visits to the institutions concerned with Healthcare waste and to various hospitals and clinics to diagnose the problem of healthcare waste management.

But the results are industrial hazardous waste in the West bank and Gaza Strip is gen-

erated mainly from print and photography shops, the use of printer toner, chemicals, and film degrading. Mechanic workshops produce waste oil, grease, brake fluid and batteries. The textile industry generates waste from dyes, chemicals, oil, grease, and other chemicals. Paper factories use bleach, glues, and auxiliary chemicals. Other industries producing hazardous waste include construction materials, woodwork, plastics, batteries, leather tanning, shoe manufacture, metalwork, electroplating and surface-coating industry and paint industries. In Gaza Strip the estimated amount of hazardous waste generated annually from the industries is 803 tons. There are at least seven industrial zones in the Jewish colonies in the West Bank. Information about Jewish industrial activities in the West Bank is limited. The total estimated medical waste produced by the non-public medical establishments is about 432 tons including 418 tons in the WB and 14 tons in the GS.

A total of 123 pesticides are currently used in Agriculture, some of which are internationally suspended, banned or regulated by the Stockholm Convention. DDT is reportedly used for fishing and used oils are employed as herbicides. Common categories of Household Hazardous Wastes (HHW) include ignitable wastes, toxic wastes and corrosive wastes. There are obvious problem in used tyre generation in the WB and GS as approximately 3 million tyres are generated every year.

There are some sources of radioactive waste, including radioactive hospital waste, potentially radioactive waste from industry, lightning rods, fire alarm equipment, and potentially radioactive material from Israeli military sources. At present, management of hazardous waste is impeded due to absence or lack of centralized facilities for recovery and treatment of waste, scarcity of information on source of hazardous waste and lack of experience lead to the wide spread practices of illegal dumping with municipal wastes.

The framework of Egyptian Environment law tackles the management of Hazardous waste in several holistic phases, namely Generation Phase, Collection and Storage Phase, Transportation Phase, and Treatment Phase.

Conclusions

There is no authorized specific body responsible for hazardous and healthcare waste management in WB and GS. Also, there is no clear procedure for managing HW or a special institutional setup to deal with HW and HCW.

There is good experience in HWM practice in the region that we can learn and benefit from.

Most of the hazardous and healthcare waste generated in the WB and the GS are mixed with municipal waste due to the bad segregation practices at the source. Accordingly, the amounts of HW and HCW increase.

Implications and Recommendations

Hazardous waste regulations (bylaws) should be developed to provide strict controls for collection, treatment, storage, transport, disposal, monitoring, and reporting of hazardous wastes and healthcare wastes.

Awareness, training and capacity building program and activities in HW and HCW management should target the public, industries and decision makers.

Pre-Treatment of HW should be performed at the source where it is being produced to minimize the quantities of hazardous waste to be treated. Pre-treatment should be performed to the National Industrial Effluent Treatment Standards. It is recommended to establish small centralized hazardous waste treatment and disposal facility.

Traditional public health practices emphasize prevention. This principle should be extended to hazardous waste management where generators of hazardous waste should be encouraged to develop techniques and processes that minimize the generation of wastes. If the production of hazardous wastes cannot be avoided, the wastes should be recycled or re-used for other purposes.

Introduce the concepts of risk assessment and life cycle assessment in tracking chemicals and waste.

Development an Integrated Water Management Strategy for Ramallah Rural Areas

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Executive Summary

Limited access to available water resources exacerbated by water quality degradation with increased population and rapid urbanization are serious challenges in achieving sustainable developmental in Palestinian communities. What water resources strategies can be developed and applied to cope with these challenges? Can an integrated water resources management [IWRM] provide technically feasible options to solve these crucial challenges? Rural communities in Al-Bireh-Ramallah district are selected as a case study.

Introduction

Safe access to and secure water supply are core elements for sustainable development in a given community. Beside financial aspects, management and institutional issues are essential for sustainable management of available water resources in Palestine. Due to Israeli military occupation, most of the Palestinian rural communities suffer from limited access to water resources. Annual degradation in water quality and poor water supply services can pose serious health and food insecurity in rural communities. The main goal of the aimed at developing an integrated water management strategy for Ramallah rural areas, so that feasible solutions to abate the water shortage problems in these areas can be established. Thus, increasing water availability by substitution the usage of fresh water resources in sectors where other available and adequate resources could be used. The integrated water management strategy envisaged studying various water sector elements, mainly; quality and quantity of available water resources, rainwater harvesting, greywater recycling and reclaimed water use in agricultural reuse schemes.

Approaches and Results

The main goal of the research study is to develop an integrated water management strategy for Ramallah rural areas aiming at establishment of suitable solutions for

the water shortage problems in these areas. Thus, increasing water availability by substitution the usage of fresh water resources in sectors where other available and adequate resources could be used. The integrated water management strategy studied various water sector elements including water quality and quantity; rainwater harvesting, greywater and wastewater reuse options.

The developed strategy stemmed from the following methodology is firstly, data are collected from different water institutions, second water quality of several springs and cisterns in the area are tested, third, a questionnaire is distributed to four representative villages which included water use patterns and consumed quantities, a waste water disposal, along with prevailing water problems. Finally, the statistical package SPSS is utilized to analyze the data. The outcome of the results is used to formulate the management strategy suitable specifically for rural areas. The results obtained indicated that in the coming twenty years the area will be facing severe water problems if ground water resources will remain the only source and if the current patterns of water used are kept. Furthermore, unconventional water resources; upon proper use and management; can supply two thirds of the domestic demand in the rural areas at half of the cost for the network water, in addition to supplying low cost water to be used for local agriculture.

Conclusions

Individual proposals within the developed integrated water management strategy formulated for Ramallah rural areas can be implemented successfully. However, all this is governed by granting a major role to local administrations and the public; applying of a financial policy that will encourage the implementation of the proposals and a legislation plan related to water issues.

Implications and Recommendations

To follow-up and monitor the outcomes for the suggested core elements of the rural water strategy, a committee shall be established jointly from concerned Ministries, PWA, JWU and a representative of the academic research institutions and NGOs in the area. This committee will coordinate the efforts, propose plans and should be supported by a technical office and financial institution, which will implement and supervise the proposed plans. Institutional reforms regards mission, governance, monitoring and operational management are crucial issues that need further investigation. There are many benefits to be gained from the use of greywater and reclaimed water that are not incorporated into this study. For example, the environmental and health benefits of treated grey and wastewater are not quantified in this study. However, the developed water strategy can be applied in other Palestinian rural communities aiming at the enhancement and further development of both water and wastewater facilities. However further detailed studies are recommended.

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Executive Summery

Wastewater management is becoming more prevalent in recent years especially in Middle East and North Africa (MENA) region as considered the most water scarce region of the world. So this research aims to develop a framework for a national Palestinian strategy for management of rural.

Two scenarios are set that are fist scenario is collection and treatment of wastewater using onsite treatment units at household level by taking three different resources: water network, water vendors and cisterns, and second scenario is collection and treatment of wastewater using collective systems at community level. These scenarios' information is achieved by distributing questionnaires to the NGOs via e-mail to gather information about implemented wastewater treatment units. The results of water consumed quantities in Palestinian rural areas as: 80%, 10% and 10% water network, water vendors and cisterns as respectively. The 383 implemented onsite treatment units treat 7% of the collected wastewater. The 10 implemented collective systems treat 0.3% of the wastewater amount. The total wastewater generation rate in Palestinian rural is 9 M m³ in 2007 that is expected to increase about 14 Mm³ in 2030. But the COD, BOD and TSS values are less than 150, 60 and 90 mg/l respectively with 3 barriers that is not suitable for even unrestricted irrigation. So if all of the wastewater generated were to be reused, it would be possible to save 14% of the supply and demand gap.

Introduction

Palestine lacks a national wastewater management strategy that can effectively protect public health and environmental quality as many developing countries. The sector of rural sanitation in Palestinian areas could be considered as a neglected sector which lacks adequate sewage systems to dispose wastewater although water scarcity is an issue for rural areas. So the wastewater must be recognized as part of the total water cycle.

About 65% of the West Bank population is not served with sewerage networks, and uses mainly cesspits and occasionally septic tanks. The other 35% is served with sewerage networks, but less than 6% of the total population is served with treatment plants (EMWATER, 2004). More than 35% of the total population of the West Bank lives in rural areas distributed in more than 450 towns and villages. Most of the cesspits enable sewage to infiltrate into the earth layers polluting the groundwater, and causing severe environmental problems and health hazards. The wastewater collection component of wastewater management accounts for 80-90% of the capital cost which makes it economically unfeasible for the dispersed pattern of houses in rural areas (Sbeih, 2008).

Appropriate management of wastewater has been neglected throughout the Occupied Palestinian Territories, both prior to and during the present conflict and obstacles; little investment has been made in the wastewater sector since the Oslo Accords. Moreover, the political situations and Israeli settlements plays major role in present conflict to reuse and progress the wastewater. However, several small scale wastewater treatment plants have been constructed in the unsewerd rural areas of the West Bank. In addition, some applied research studies of biological treatment systems for small rural communities were recently installed and studied. The only organizations involved in the construction process are NGOs with international funds (EMWATER, 2004).

Decentralized wastewater management will be proposed strategy to manage wastewater in Palestinian rural that is a much greater potential for the treated wastewater to be generated closer to the potential reuse sites and less political complications with the Israeli side than centralized approach.

Approach and Results

Applied methodology is conceptual framework for assessing wastewater generation, disposal, treatment and reuse in Palestinian rural areas using three water sources for consumption within households. Amounts of wastewater generated, treated and reused were calculated for year 2007. Flow generations were projected to different periods till year 2030. And also, the amount of water quantity from network, cisterns, vendors, onsite treatments units and collective systems are estimated by using equations with their cost and percentages of water deficit compensation. Two scenarios are applied that are collection and treatment of wastewater using onsite treatment units and second scenario is collection and treatment of wastewater using collective systems at community level. Under the first scenario two options are reuse for garden irrigation with selected crops and the reuse for toilet flushing. But the second scenario has several potential reuse options as reuse for forests and landscape irrigation, reuse for agricultural crops, reuse for groundwater recharge, reuse for industrial purposes and reuse for potable purposes.

Water stress is an issue for rural areas, 123 communities out of the 395 rural communities does not have water network as the blue color. Generally, total wastewater generation rate for 2007 in Palestinian rural areas is 8,975,513.3 m³/year, and it is estimated that the average wastewater generation rate will increase to 13,928,964.5 m³/year by 2030. Decentralized wastewater management will be the proposed strategy to manage wastewater in rural Palestinian areas that has low construction cost between 78.7 – 157.4 million \$ which is much lower than the investment cost required for collective systems which ranges from 203,725,000.0 – 245,875,000.0 \$. This cost could increase by 20 % for onsite units, in order to accommodate future growth. The first scenario of reuse - using onsite treatment units at household level - is the most practical scenario. The proposed reuse option is the home garden irrigation of fruit trees and flowers planted around houses for the 357 communities out of the 395 rural villages. Within the first scenario, although reusing effluent in toilet flushing could save 3,065,029 cubic meters annually, but this will require a dual system hence, the level of complexity of treatment and operation of grey water systems designed to produce water for toilet flushing is considerably more complicated than for garden irrigation, and leads to increased operation and maintenance costs. Home garden irrigation will save 2,253,698 cubic meters annually but will be easier to implement, so it is adopted to reuse around houses, with the type of crops to be planted and irrigated by the effluent is the fruit trees and flowers.. Within the second scenario reuse with crop irrigation will save 1,077,244 cubic meters annually.

Conclusions

This research has shown if all generated wastewater by Palestinian rural areas were to be reused as an unconventional water resource, it would be possible to bridge the supply and demand gap by 14%. So Ramallah is considered good candidate for the implementation of water reuse that water deficit is 34% generated wastewater quantities. But the investment cost is much higher that is required to implement collective systems (including the sewerage lines) to treat the whole amount of rural wastewater will range from 203,725,000.0 – 245,875,000.0 \$ higher than onsite treatment needs that is ranges between 78.7 – 157.4 million \$. Therefore, decentralized systems will be proper collection method in Palestinian rural.

Implication and Recommendations

Given the blooming water resource crisis, wastewater should be recognized as part of the total water cycle and therefore managed within the integrated water resources management process. The framework onsite treatment units should be maintained and monitored to control pollution to recover water for non-potable water uses. Periodical supervision and monitoring and quality analysis concerning the onsite treatment units should take place in order for these units to achieve the expected results. For any reuse project to be implemented, the goal of the project should be first set. Priority for the most stressing issue of the country that should benefit from the reuse has to be identified through stakeholders' participation.

There is an essential need to be more studies to ensure that health and environmental risks are minimized.

Geographic Information System (GIS) could be used as a proper tool to identify threats to the aquifer, to illustrate suitability of areas for agriculture and agricultural value.

On the Sustainability of Rural Wastewater Management Systems in Al-Bireh/ Ramallah District

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Executive Summary

Lack of financial national funds and inequitable political power placed domestic wastewater management in Palestinian rural communities at a second priority within the Palestinian water strategy. In all Palestinian small communities, existing onsite sanitation facilities are inadequately designed, poorly sited, and rarely maintained over their service life cycle. Furthermore, the lack of experienced technical staff by the water related Palestinian institutions responsible for technical review and licensing as well as the outdated local municipal regulatory codes still facilitate and promote the continued use of such onsite systems.

This research study highlighted practical tools for the proper selection of sustainable onsite sanitation systems in Palestinian rural communities with a population number of equal or less than 5000 capita. A specialized questionnaire is developed and distributed to 200 households in four randomly selected villages with less than 5,000 persons and having onsite sanitation facilities. WAWTTAR software package is used to evaluate 16 different treatment systems and to select a sustainable onsite treatment system for these rural areas based on technical, environmental, financial and socio-cultural considerations.

The findings of this study indicated that most of the respondents favored using treated grey wastewater and equally rejected the use of mixed treated effluent for agricultural irrigation. Contrary to researcher's expectations, more than

50 percent of the respondents voted against installing decentralized sanitation systems and favored centralized wastewater treatment options, as only 18 percent showed willingness to participate partially in construction costs. The WAWTTAR data analysis on feasible onsite treatment alternatives revealed that septic tank-subsurface wetland system offered a higher level of sustainability to rural communities in Al-Bireh Ramallah district. Finally, adequate selection of onsite sanitation services and performance improvement of current decentralized wastewater systems provide health and water resources protection in rural Palestinian communities.

Introduction

In Palestinian rural communities water and financial resources are not available to establish centralized conventional wastewater services. So, application of decentralized management approach within the water cycle and the use of low cost sewerage are more suited to the socio-cultural and environmental circumstances. Proper selection of new and performance improvement of current onsite wastewater treatment systems provide health and water resources protection in rural Palestinian areas.

There is substantial need for more sophisticated management of both on-site septic systems and small community wastewater treatment and disposal systems. While these systems are fairly easy to maintain, it is clear from recent studies that these systems have not always been maintained properly. Better management should facilitate more extensive use of complex technological options. There are a number of institutional management entities that can be used depending upon the needs and desires of the county or local community.

The main goal of this research study is to develop a sustainable wastewater management for small communities in Al-Bireh/Ramallah district. This research study is limited to those Palestinian rural communities with a population number of equal of less than 5000 residents.

Approaches and Results

Decentralized wastewater treatment systems reduce public health risks and preserve water quality if they are properly selected, well designed, properly installed, and effectively managed. The selection of adequate sanitation facilities, in this study, will

take into account the environmental and socio-economical aspects of the residents in the small communities of Al-Bireh/Ramallah. However, these aspects can be community specific and might vary from one district to another; a brief analysis of these aspects is made for all Palestinian districts.

A specialized questionnaire is developed and distributed to 200 households in four randomly selected villages with less than 5,000 persons and having onsite sanitation facilities. WAWTTAR software package is used to evaluate 16 different treatment systems and to select a sustainable onsite treatment system for these rural areas based on technical, environmental, financial and socio-cultural considerations.

Major findings indicated that most of the respondents are in favor of using treated grey wastewater and equally rejected the use of mixed treated effluent for agricultural irrigation.

More than 50 percent of the respondents are against having new onsite treatment systems and favored centralized wastewater treatment options, as only 18 percent showed willingness to participate partially in construction costs. The WAWTTAR data analysis on feasible onsite treatment alternatives revealed that the septic tank-sub-surface wetland system offers a higher level of sustainability to rural communities in Al-Bireh Ramallah district. Finally, the socio-economical aspects have an equal status in technical and financial issues.

Conclusions

The conclusions are made based on the methodology applied and results obtained in this research study that are adequate selection of decentralized wastewater treatment systems is governed by proper application tools as WAWTTAR software package, consideration of technical, environmental, financial and socio-cultural issues pertinent to technology selection dictate sustainability of onsite treatment systems and technically septic tanks with constructed wetlands are feasible, while socio-cultural aspects favored onsite systems with greywater use.

Implications and Recommendations

Sustainability of rural onsite sanitation systems is governed by technically feasible, environmentally sound, and financially affordable technologies. The results obtained can be utilized by local and international experts seeking a carrier in the

planning and design of sustainable sanitation facilities in developing countries or for those who have newly filled a post in governmental, non-governmental or academic institutions.

Public consultation and community participation should be made in early planning phase to guarantee sustainable decentralized sanitation facilities. Finally, proper selection of new onsite systems and performance improvement of current decentralized wastewater systems provide health and water resources protection in rural Palestinian communities.

Technical and Economic Feasibility of Biosolids-Amended Brick Production

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Executive Summary

This research study investigates the technical viability of incorporating dehydrated biosolids and sewage sludge ashes into concrete raw material mixtures to produce pre-cast bricks that can be utilized in general-purpose outdoor building of non-load bearing structures. Furthermore, the cost-cutting benefits of producing such sludge-amended bricks are quantified. The approach was to experiment with the addition of various sludge quantities to concrete mixtures-(making use of both sun-dried biosolids and sewage sludge ashes)- and then to evaluate and analyze the corresponding physical properties of the concrete mix paste and of the produced concrete bricks- mainly those properties affecting structural integrity.

Results showed that there is a general inverse relationship between the amount of dried sludge or ashes added and the compressive strength development of the cured blocks. However, the addition of as much as 10% of biosolids' ashes to the raw ingredients of a concrete mix did not affect the general physical properties of concrete (i.e. the workability of the concrete mix and the compressive strength, water absorption, and density of the cured bricks). On the other hand, the addition of an equal quantity of sun-dried biosolids decreased the compressive strength of the cured concrete by about 20% - which can be attributed to the presence of the organic materials in the dried biosolids. Moreover, results showed that there is no significant change in the relative strengths of the tested concrete blocks when sludge is used in small quantities (i.e. 10% ashes or a combination of 2.5% dried biosolids and 7.5% ashes) as sand replacements in the concrete mixture. For concrete bricks' manufacturers that utilize

sand as a raw material ingredient in their production process, the incorporation of 10% sewage sludge ashes into concrete mixtures as a partial replacement for sand can achieve the highest possible monetary savings.

Introduction

Wastewater treatment and the management of the solids (in the form of sewage sludge) that it produces are intricate global issues with growing challenges that must be addressed at all levels of stakeholders – wastewater generators, sanitary engineers, treatment facility operators, scientists, regulators, as well as the general public. In Palestine for example, only 52.1% of households are connected to functional wastewater networks. Moreover, cesspits are still in use by more than 45.5% of Palestinian.

Biosolids' disposal in landfills in the EU, for example, has directed the phasing-out due to concerns pertinent to methane release; a potent greenhouse gas. Worldwide, wastewater sludge is a valuable resource to landfill, which is not considered a beneficial use of biosolids. Austria and Germany sludge land filling is not allowed if it contains more than 5% total organic carbon by dry weight. Literature data reveal that the average total costs of sludge disposal and recycling in Europe with land spreading routes as the best ranking while land filling and incineration are the worst ranking disposal routes in terms of overall cost. In Palestine, increased amounts of biosolids pose serious environmental and economic challenges considering lack of legal, administrative and technical rules and guidelines regards beneficial uses and safe disposal routes. Despite few local research trials of using biosolids as a fertilizer and composting pilots little is known about the long-term impacts on soil, groundwater and produce. As increasingly stringent environmental-control mandates are introduced and enforced, the traditional disposal routes of land application, landfilling, and incineration of processed biosolids will come under pressure and may no longer be viable and cost-effective disposal outlets for sanitary engineers to capitalize on. Furthermore, the extraction of natural aggregates (i.e. sand, rock, and gravel) for use in building materials is associated with detrimental environmental impacts – with some countries moving to impose taxation laws on such excavation practices. As a result, the viability of using alternative aggregates - such as biosolids - as building materials is expected to increase.

The potential reuse of wastewater biosolids and incinerated sewage sludge ashes as additives into construction materials may alleviate sludge disposal problems and offer economic, ecological, and energy saving advantages at the same time. The main objective of this work was to investigate the technical and market potential of pro-

ducing precast concrete bricks that are amended with stabilized sewage sludge as well as with incinerated sewage sludge ashes. The feasibility of incorporating biosolids and biosolids ashes into the manufacturing process of concrete bricks without affecting the physical properties of the cured concrete could offer an economical sludge disposal option.

Approaches and Results

In this study, the incorporation of sewage sludge and sewage sludge ashes into concrete blocks is systematically investigated. The approach is to experiment with various sludge dosing ratios (making use of both solar-dried biosolids and sewage sludge ashes) and then to evaluate and analyze the corresponding physical properties of the concrete mix paste and of the produced concrete bricks – mainly those properties affecting the structural integrity of the cement mix and of the cured concrete. Physical property results are then compared and contrasted against those for pre-cast concrete bricks that are free from any biosolids or sewage sludge ashes (i.e. control samples). The effect of the addition of the solids to the concrete mixture is analyzed and an optimum biosolids-amended concrete mixture is selected (one of 0 – 10%, 10 - 20%, or 20 – 30%) based on an acceptable compressive strength value. The water-cement ratio (w/c) has an important influence on the quality of concrete produced. A lower water-cement ratio leads to higher strength and durability, but may make the mix more difficult to place. As a rule of thumb, for every 1% increase in the quantity of water added, the concrete strength is reduced by 5%. Following the addition of 20 liters of excess water per cubic meter of concrete, the final achieved strength may be as low as 50% of the desired strength.

When compared to the control sample (specific strength 100%), results clearly show that there is an inverse relationship between compressive strength and the quantity of dried biosolids added. On the 7th day of curing, the samples containing 30% biosolids showed weakened strength by as high as 30%. Samples containing 10% dried biosolids showed a decrease in compressive strength by about 13% on day 90. It is imperative to compare the effect of the addition of sewage sludge on the different grades of concrete. The effect is clearly demonstrated at high quantity (i.e. 30%) of dried sludge added to the mixture.

Adding 10%, 20%, and 30% of incinerated biosolids as an additive to the concrete mixture, the average compressive strengths of cured concrete blocks are determined. Results indicate that the addition of 10% of biosolids ashes to the concrete

mixture had no significant effect on the 7- and 28-day compressive strengths. The compressive strength at age 90 days is reduced by 4%. The addition of 30% biosolids' ashes had a more considerable negative effect on the 7th and 28th curing ages.

Conclusions

Stabilized sewage sludge (biosolids) and sludge ashes cannot replace the cement constituent of a typical concrete mixture as neither of them contains the binding agents that are present in cement. However, biosolids and sludge ashes can be added in limited quantities as additives or as sand replacement to a typical concrete mixture without having considerable negative effects on the structural integrity of the cured concrete.

The lowest negative effect is a 13% compressive strength decrease when 10% dried sewage sludge is incorporated into the concrete mixture. The maximum damaging effect occurred when adding 30% dried biosolids that resulted in a 40% decrease in the load bearing capacity of concrete.

The addition of biosolids ashes to the raw material concrete mixture in small quantities (i.e. no more than 10%) had no significant negative effect on the compressive strengths of the cured blocks recorded on the 7th and 28th days of the curing age. The compressive strength at day 90 showed a 4% decrease. The most economic option for producing bricks that are amended with biosolids is to use incinerated sewage sludge ashes as a partial replacement for the sand in the raw material mix-design. Using 10% sewage sludge ashes as a partial sand replacement can cut raw material cost by up to 15%.

Implications and Recommendations

The implications and recommendations can be made the hydration chemistry of sewage sludge and biosolids ashes should be investigated and compared to the pozzolanic reactions of cementitious products such as cement to better understand if ashes could augment the strength concrete.

Government biosolids policy should aim at driving supply and demand for cleaner production and green technologies. Lower taxes, tax credits, and subsidies could be possible key drivers that may be used to stimulate the marketplace for greener production technologies and drive innovative use of biosolids in construction industry. Finally, for cost-cutting purposes, a few concrete production facilities in the West Bank are not using sand in their concrete mixture, but finely-crushed limestone as a sand replacement.

Households' Affordability and Willingness to Pay for Water and Wastewater Services in Ramallah and Al-Bireh District, Palestine

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Executive Summary

This study has analyzed and evaluated the current water pricing policies in Ramallah and Al-Bireh District, which do not satisfy the full cost recovery principle. An important aspect in analyzing current pricing policies is calculated the true cost/ benefit values for investment, operation & maintenance, unaccounted for water and depreciation in order to determine the efficiency of the current tariffs in water utilities. Moreover, it looked for Public affordability and willingness to pay that should be assessed towards judging sufficiency of these policies. Area under study is Ramallah and Al-Bireh District; under the occurring political situation it is difficult to move within the district. The current increasing block tariff system applied by Jerusalem Water Undertaking (JWU), and the other providers in the district is ranged between (4 -7) NIS/m³, the majority of the population surveyed did not understand how block system functions and most of them replied that they are not willing to pay any higher amount than 5 NIS/m³ for water services, whereas the same sample replied that they were willing to pay a higher price for disposal of the wastewater.

Consequently, conducting this study is difficult as it is based on a field survey involving the distribution of a questionnaire and an analysis of the results in order to build a model that shows valid understanding of affordability and willingness of consumers to pay their water bills.

The main objectives of this research are to evaluate current tariffs for water and wastewater services, suggest modifications if needed, and find the factors affecting

tariffs. These are achieved by conducting a questionnaire survey, analyses of the results using SPSS software, and then two models are constructed to check the hypothesis based on both categorical data analysis, in addition to multiple linear regression.

Results analysis revealed that current tariffs need adjustment and that the proposed variables are significant to willingness of consumers to pay for water and wastewater fees. It can be said that socio-economic status of residents had no significant impact on their willingness to pay for wastewater or water significantly. However, there are many other determinants that affect consumer willingness to pay for water services, such as: Knowledge of price paid per cubic meter of water, cost of emptying cesspits for inhabitants who rely on cesspits for sewage collection, availability of water from other sources, and payment methods used to settle the bills. The percentage of what is paid for water bills to the total income ranged from 4.99% to 5.89%, which are not contradicted with the hypothesis stating that 3-5 % of the income is spent on water bills. The analysis also shows that income is not a variable of influence, as it has a confidence value not less than 0.05 which is the opposite of the hypothesis.

Introduction

The existing water supply systems in Palestine are characterized by high leakage, intermittent supply, and thus need rehabilitation. In addition, about 45% of the Palestinian territories lack for sewerage networks and wastewater treatment systems (PCBS, 2006). This is mainly attributed to lack of financial resources for the construction and operation and maintenance of these systems. The financial performance of both sectors is characterized by over-reliance on external financial aids and lack of local financing. However, these communities paid for water and sanitation. The existing tariff systems employed a block structure. Water and wastewater services are considered as an economic good, this implied a price, prices are derived from tariffs and tariffs are suggested and formulated in accordance with the adopted water policy. Still all water projects have the same economic components as any other project: investment, operation and maintenance, depreciation, losses (Un-accounted for water), costs, benefits ... etc. Water fees for domestic water supply varied considerably among different localities. Tariffs ranged between 1.0-1.2 \$/m³ in Ramallah area. In Ramallah area for example where water tariffs are highest, water is conveyed long distances and/or pumped from deep wells (EMwater, 2004).

The already planned wastewater treatment plant (extended aeration system) for the urban areas in Palestine revealed that the tariff for wastewater treatment would be 6 NIS/m³ if full cost recovery would be fulfilled (this cost is 1 to 1.3 higher than the cost of 1 m³ of drinking water). If only O&M cost is to be recovered, the tariff would be 2 NIS/m³ (EMwater, 2004). The average household cost of conventional sewage may range from \$ 300-1,000. This is clearly too expensive for many households with annual incomes well below US\$ 300. If a septic tank with 5 m³ volume installed, its capital cost would be 1,000 \$ for installation, and pumping it for O&M once every 3-1/2 years will cost 2.08 \$/month. It should be mentioned that the water pricing policy is based on political decision, and the above economic components are taken slightly into consideration, which resulted in the fact that cost are not fully recovered (Plaut, 2000; PWA, 2005; Hind, 2003). In addition the policy did not take into consideration the affordability and willingness of people to pay (PWA, 2005; Hind, 2003).

The current water and wastewater services situation are discussed in terms of tariff financial information, with the main goal of providing guidelines for Palestinian policy-makers to develop an accountable water pricing policy based on recovery of costs and willingness of people to pay. The specific research objectives are evaluating the existing tariffs for water and wastewater services, estimating the existing costs for water and wastewater services, assessing the affordability of beneficiaries to pay for water and wastewater services, eliciting the willingness of beneficiaries to pay for water and wastewater services, understand the various incentives that drive public decisions and willingness to pay and creating a flexible model that could be adjusted to cover the Palestinian territories, which can be used to test suggested tariff policies. The research can be achieved these objectives by adopting the methodology of evaluation available technical data on current tariffs and water and wastewater prices, questionnaire development and distribution to investigate the social and economical aspects of Ramallah and Al-Bireh District community concerning their affordability, and willingness to pay for water and wastewater services and application of SPSS software package to develop a model that can suggest the most relevant factors affecting household's affordability, and willingness to pay.

Approach and Results

A field survey is carried out based on a designed questionnaire, aiming at obtaining more data about the willingness and affordability of the population. The technique of applying field surveys by using questionnaires is not new; statistical models using

the SPSS software is employed to study potential correlations between households' income and their expenditure on water and wastewater services. These expenditures are based on the current as well as the various proposed tariffs. The analysis of this model will help in the assessment of current policies. The data is entered and analyzed using multiple linear regression analysis, then checking the hypotheses.

The field survey has been conducted in the Ramallah and Al-Bireh District. This survey covered 400 households representing the various categories of the Palestinian communities; cities, towns, villages, and refugee camps. A questionnaire has been developed and pilot-tested on (50) households prior to conducting the actual survey. The questionnaire consisted of (51) questions, the answers of these questions are formulated in reference to specific resources. Participants are carefully selected to represent a cross-section of socioeconomic backgrounds and a range of water and wastewater conditions. The discussions focused on participants' experiences with water and wastewater services, the perceived quality of the services, the characteristics of services that are important to participants, and the language they used to describe their experiences.

The data collection effort consisted of designing contingent open-ended questionnaire, selecting an appropriate sample for the survey, and administering the survey effort. Qualitative research provided an understanding residents' experience with water and wastewater services and contributed to development of a questionnaire that communicated unambiguously with respondents. Quantitative research consisted of a survey of Ramallah households. The qualitative work demonstrated that Ramallah residents are aware of the importance of the services, but they did not accept that the services are economic goods. The questionnaire is designed to be administered as a door-to-door personal interview.

Two SPSS models are applied for both types of services; the first model is multiple linear regressions, and the second is categorical data analysis.

Conclusions

Based on this hypothesis as current water pricing policies are not sufficient, and needs adjustments and assumed that the following factors affect the willingness to pay for water services and wastewater services. But the water services can estimated the income, water supply source, monthly water bill ,times buying from other sourc-

es, knowledge of price paid per m³, what do you think of illicit connections ,means of paying water bill.

Furthermore, the wastewater services can be estimated income, water supply source, monthly water bill, times buying from other sources, knowledge of price paid per m³, suitable monthly average bill of sewage , method of sewerage collection , how many times you empty your cesspits ,cost of emptying the cesspit /month.

And also, the other hypothesis is assumed that water bill is in the range adopted by the World Bank (3-5%) of the total household income. So this research concludes WTP is not related to income, as people were not giving their total true income for different consideration, this is proved by the multiple linear regressions, and the categorical data analysis. The most significant variables on the WTP for wastewater are: monthly water bill, times buying from other sources, knowledge of price paid per m³, suitable monthly average bill of sewage, times of emptying cesspits, cost of emptying the cesspit /month.

The socio economical factors are not the significant factors for determining the WTP for water and wastewater services.

If the population are provided with wastewater services, some are willing to pay higher than the current tariff for the service; this depends on the degree of people awareness of what they have to pay for the services. This is proved by the fact that people aren't willing to pay higher tariffs for water services as they think the current tariffs are expensive. Few people refused to fill the questionnaire as they thought that it has to do with income taxes, or it might cause an increase in services tariffs which they consider to be high already. Many people thought the district had no problem concerning wastewater services.

Water bill percent to total income ranged from 4.99% to 5.89%. Concerning the issue of full cost recovery none of the Municipalities discussed are applying the principle of full cost recovery for different reasons: Social, Financial, and Political, technical ... etc. Water tariffs applied are not sufficient according to the comparison presented. To finalize, it could be said there is no consciousness and awareness from people to the unforeseen impacts and dangers for neglecting wastewater collection and treatment issues, people are only willing to pay whenever they are feeling harm and suffering from it.

Implications and Recommendations

- Public Targeted Awareness program should be performed for both water and wastewater sectors, aiming at increasing the knowledge about the real costs of the services provided.
- The Authorized party should consider reducing prices as tariffs are high which was found via field survey that might be done by applying the policy of integrated water resources management, and applying the appropriate means of resources conservation.
- Reduce consumption by using the appropriate affordable instruments and encouraging the population of the district to use them. Increasing the quality of services might convince people to pay higher tariffs.
- Review the pricing policy in relation to social blocks, lifelines and to support alternative service providers.
- Clarify ownership and agree on responsibilities for operation and maintenance, especially the cost implications for infrastructure to be managed by communities.
- Determine how cost recovery and cross subsidy will be handled within the utility and between internal sources and external sources of income. And also, prioritize; allocate resources from revenue generation to low income communities.

Development of Basic Indicators on Integrated Water Resources Management: West Bank as a Case Study

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Executive Summary

Indicators improve the water resource management policies by providing a better assessment of the water resources. Indicators on Integrated Water Resources Management (IWRM) are comprised of measurements and derived values that track the changes of water resources conditions. In this research, the IWRM indicators for the West Bank are developed in accordance with the IWRM indicators in the ESCWA region. The IWRM indicators are suitably developed to fit with the reliable and available data in the West Bank. The water status is analyzed in line with the Driving-Force-Pressure-State-Impact-Response (DPSIR) framework. The IWRM indicators for the West Bank are developed and categorized into four groups: enabling environment and institutional roles indicators, supply availability and management indicators, demand management and protection indicators and health and environmental protection indicators.

Introduction

With the fast growing population, urbanization, food security policies and the growth of development and economic activities devouring available water resources, integrated management of water resources is becoming a serious concern. The galloping rise in demand associated with the rapidly changing patterns of water use indicates that the availability of water can no longer be taken for granted. Moreover, water use in the immediate future will be subject to governed by the increasing scarcity in various parts of the Economic and Social Commission for Western Asia "ESCWA" countries. Pollution further exacerbates water scarcity by reducing water usability downstream. Hence, the enormous consumption of freshwater sources, namely, surface water and groundwater, is not only due to excessive use and overdraft. The

situation becomes critical when such impacts are superimposed on the harsh climatic condition prevailing in the region.

Indicators are important in water management, they are necessary to understand the process of change, and help decision makers understand why change is taking place. Indicators on IWRM are comprised of measurements and derived values that track the changes of water resources conditions and their management efforts and success/failure over time. They help measure the state of water resources in general, the pressures exerted on them, and the resulting impacts on ecological and human health. More importantly, such indicators show progress of developing measures and policies aiming to protect and sustain water resources. The unique historical water situation in Palestine has resulted in a low per capita water demand. Water supply is generally constrained due to technical, institutional and political limitations. Water has been a major issue in the Palestinian-Israeli negotiations since the early 1990's, but up to this day, little progress has been made. Currently, the water problem remains one of the most debatable issues waiting to be resolved between Israel and Palestine. The current water crisis is not only a consequence of water scarcity in the region, but also an inherent part of the general Palestinian-Israeli conflict.

Approaches and Results

The methodology of the research combines standard data gathering and analysis of the water situation of the West Bank, data is collected through desk research of secondary sources. The indicators were developed by the researcher in reference to the Al-Zubari (2004), the Water Development Report-2 (ESCWA 2007), and the groundwater indicators which were presented on the Groundwater Resources Sustainability Indicators (2007) created by the UNESCO. Moreover, new indicators are developed to reflect the current water situation in the West Bank.

The indicators development is carried out through personal communications conducted with experts from related sectors. The researcher met the decision makers, the list of indicators are discussed, the indicators that don't fit with the Palestinian situation and data availability are excluded, while the indicators that applied to the West Bank are selected and re-examined. Some of the indicators' values are direct numbers or percentages while others are calculated values. The developed indicators are categorized in line with the IWRM general framework, which includes four groups; enabling environment and institutional roles indicators, supply availability and management indicators, demand management and protection indicators and health and environmental protection indicators. The values of the indicators are compared with the values of the ESCWA countries in order to determine the status of the West Bank and the action plan needed.

The water scarcity indicator is used to monitor the average individual share of water resources in the country. The total annual available water resources are adoption as annual abstraction by Palestinians from the three basins in the West Bank which is 121 Mm³ yearly. So, the Water Scarcity Indicator in the West Bank is 51.47 m³/cap/yr. An Important IWRM indicator is availability of water resources which includes the available conventional and non-conventional water resources, "dependency ratio" and "water harvesting"; each indicator measures the significance of non-conventional water vs. conventional water resources as components of total abstraction water resources in the West Bank.

The West Bank depends on the groundwater resource for its water supply. The groundwater recharge as a percentage of total renewable water resources indicator is a significant factor which affects national IWRM frameworks and policies with respect to necessary investments, energy costs, water sectoral and geographical allocation, etc. In the West Bank the groundwater recharge consists 100% of the total renewable water resource which is similar to the Bahrain and Kuwait countries, while the average groundwater recharge in the ESCWA countries is 10.2% of total renewable water resources. Treated wastewater reuse is such a small amount due to lack of efficient treatment plants and lack in wastewater reuse concepts, importance and required technologies.

Efficiency of water use indicators includes "unaccounted water usage (domestic)", which reflects the amount of water loss. It helps assess management efficiency in urban centers, and the amount of repair the distribution system needs. In the West Bank it averages 37%, and this is the highest in the region compared with Jordan and Egypt, at 14 and 27% respectively. Overall, this implies poor management, inadequate operations and underinvestment in maintenance.

The agricultural sector is fundamental for the revival of the Palestinian economy. To that end, there are many steps that could be taken in the near future, such as; the technology transfer agenda, and developing plans for wastewater reuse in tandem with investing in water treatment. The per capita agricultural water use is only 45 m³/capita/year, while in other neighbouring countries it is 101.6, 914.3, 227.7, 845.3 m³/c/y for Jordan, Egypt, Lebanon, and Syria respectively.

The entire population in the Gulf Cooperation Council (GCC) countries, except Oman, has full access to safe drinking water. In the remaining ESCWA member countries, accessibility of population to safe drinking water ranges from 21% for Oman to 97 and 90 % for Jordan and Syria respectively. The West Bank achieves a very good percent with 90% for population with access to safe drinking water. With respect to sanitation services, there is practically full coverage of 100% accessibility for populations in Kuwait, Qatar and the United Arab Emirates. The level of

services in the remaining countries ranges from 38% in Yemen up to 89% in Oman and Syria. Provision of sanitation services in the West Bank is only 31% which makes it the lowest percent of the ESCWA countries.

Conclusions

The main findings of this research can be summarized as the case in Bahrain and Kuwait, the groundwater recharge in the West Bank comprises 100% of the total renewable water resource, while the average groundwater recharge of the total renewable water resources in the ESCWA countries is 10.2%.

The groundwater recharge as a percentage of total renewable water resources indicator is 100% in the West Bank, while the only non-conventional water resource is treated wastewater and it only forms 0.033% of total renewable water resources.

Efficiency of Water use as the unaccounted for water in the West Bank average is 37%, and this is the highest in the region compared with Jordan and Egypt 14% and 27% respectively. This indicates in general poor management inadequate operations and underinvestment in maintenance.

Water reuse is widely applicable in the ESCWA region; however, specific techniques or levels of treatment depend on local priorities and economic feasibility. The amount of treated wastewater reused for irrigation is as low as 0.18%.

The average agriculture GDP of the ESCWA countries account for 8.0% of the total GDP, while is the average in the West Bank is 8.2%, which is projected to increase through networking and planning with related sectors. 90% of the population in the West Bank has access to safe drinking water which is among the highest percentages in the ESCWA countries. And also, provision of sanitation services in the West Bank is only 31% which is the lowest percentage compared to the ESCWA countries.

Implications and Recommendations

The holistic nature of the IWRM in the West Bank requires constant knowledge exchange between the West Bank and other ESCWA member states. It also requires continuous upgrading and updating of the available information of the effective policy measures database. Such objectives can only be achieved through a set of suitable indicators that reflect the water resources situation in a dynamic and realistic manner.

Although the challenges facing this sector are multifaceted, the consequences and risks of inaction are even greater. It is recommended that decision makers and leaders in the water sector pool their efforts with their peers in the government, the private sector and civil society in order to manage water resources and achieve the set socioeconomic and environmental objectives.

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Executive Summary

Water resources in the Middle East are under enormous stress, due to an increase in population growth and the extensive use of water resources, which exceeds the water demand in this regional bloc. Moreover, climatic changes pose another dimension of stress on water resources; these changes have significant environmental, social, and economic effects. In fact, the governance of these countries has the tendency of increasing this stress or decreasing it, depending on its performance and efficiency in applying policies, legislation and managerial plans towards decreasing the poverty and the vulnerability of the countries specially those suffering from poverty. In this research, the vulnerability of five countries-Israel, Jordan, Lebanon, Palestine and Syria—have been assessed based on the extent of climate changes and the type of climate governance and their effects on water resources. The research introduces a new index, which is called the Governance and Climate Vulnerability Index (GCVI). The index measures the vulnerability of each country vis-à-vis water-related issues, while taking into account governance and climatic indicators. The vulnerability of these countries has been ranked, for purposes of comparison. The research concludes with recommendations for governments to develop appropriate water resources management and to improve their environmental policies.

Introduction

The world's climate is continuing to change at a rate that is projected to be unprecedented in recent human history. Climate change is a very real phenomenon that will inevitably affect human populations in the coming decades, and is expected to do so in the near future. Water is

involved in all components of the climate system (atmosphere, hydrosphere, land surface and biosphere). Policies for development and environment are evolving as tools of behavioural change throughout the world, and it is now understood that an essential prerequisite to effective policymaking is accurate monitoring backed up by rigorous interdisciplinary science.

In the Middle East, water resources are under enormous stress as a result of population growth and the extensive use of water resources that exceeds the water demand of the countries. This stress might grow further in countries that suffer from poverty and have limited social capacities. These factors have a large impact on the ability of the countries or communities to adapt strategies and alternatives for managing and saving their water resources.

Climate change has significant environmental, social, and economic effects in the Middle East region. Developing countries tend to be more vulnerable to these changes than other countries. In order to develop strategies for adaptation to these global changes, it is necessary as a first step to make reliable and consistent assessments of vulnerability. This needs to be holistic, at the appropriate scale, and to integrate a wide range of relevant factors. Assessing the vulnerability in the Middle East region in relation to climate change that tackles water resources governance has to be introduced to this assessment since it has a great role in influencing the ability of nations and countries to cope with changes through its policies and adaptation strategies. In this research, the vulnerability of five countries -Israel, Jordan, Lebanon, Palestine and Syria- will have been assessed, based on the extent of climate change, as well as the type of governance in each country. Further, the effects of both climate change and governance on water resources have been evaluated. The research introduces a new index, which is called Governance and Climate Vulnerability Index (GCVI).

Approaches and Results

To overpass any changes in terms of climate or governance aspects on a country level and be able to cope with the different variations, there should be an appropriate application for an integrated water management. In this research, GCVI has been developed to form a comprehensive analytical approach that provides an integrated assessment of the impact of climatic and governance aspects on the vulnerability of the five countries. This is made by incorporating climate and governance vulnerability indicators to form a complete tool for water management. The index aims to assess the social vulnerability vis-à-vis governance performance, in hopes that it will facilitate the analysis of impacts of the performance of governance on society and on each country's water resources. Consequently, these analyses can make it possible to rank countries—or communities within the same country—to prioritize the needs for interventions, taking into account the physical, governmental, environmental and socio-

economic factors associated with water. Therefore, these factors enable decision-makers—i.e. national and international organizations that are concerned with water provision—to identify the most vulnerable countries or communities, so that adaptation strategies can be developed and populations can be protected.

In this research, social and physical indicators that encapsulate human vulnerability have been adapted from the Climate Vulnerability Index (CVI) created by Sullivan (2002) and Sullivan et al. (2005). These indicators are mainly represented by water resources, use, access, capacity, environmental and geospatial indicators. On the other hand, governance and political aspects have been represented in a variety of indicators; have been adapted from the World Bank. These indicators include voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. These factors will be combined and be called the Governance Index (GI).

These two indices, CVI and GI, are combined using the Multilevel trade-off analysis using a Composite Programming approach (Distance-Based Technique) developed by UNESCO (1987), to form the Governance and Climate Vulnerability Index (GCVI).

The results show that the most vulnerable country of the five—in terms of governance and climate—is Palestine. Palestine is currently under Israeli occupation, and thus does not have full control over, or access to, its water resources. However, the political situation and the unstable governmental conditions in Palestine are playing a huge role in worsening the socio-economic conditions. Consequently, Palestine's capacity to manage and develop the country with all the resources available and its ability to develop adaptation strategies has been greatly compromised.

The GCVI has given a wider idea of vulnerability of these countries vis-à-vis water resources. Vulnerability is linked to the performance of governance. The index has attempted to illustrate this fact and to give an idea of how weak governance performance increases the vulnerability of the country, which is presented in the low value of its index. GCVI shows how the vulnerability of countries can be affected by the performance of the type of governance. For example, if one of the countries is considered less vulnerable in terms of any climatic changes (i.e. a high CVI value), yet it has weak governance (i.e. a low GI value), then the GCVI of that country will be considered vulnerable because of the performance of its governance that affects its ability to cope with climate changes. On the other hand, governance might influence the climate vulnerability through its effective water resources management, its use of water in all the sectors, its introduction of devices to conserve water, its environmentally-conscious policies, its introduction of new water sources such as reusing treated wastewater, etc. These strategies and others are a reflection of good adaptation measures that are introduced through good governance.

Conclusions

Development of the GCVI and its application to five countries has demonstrated the generic applicability of this tool. It has established a comparison method in the governance performance of the countries and its vulnerability to climatic changes, particularly in the water sector. Vulnerability intersects with governance performance, the latter of which can vary according to the political situation of the region. This makes it possible to rank countries taking into account the physical, political, environmental, and socio-economic factors associated with water scarcity. The GCVI will enable decision makers (i.e. water and environmental ministers) who are concerned with water provision, to identify the vulnerable countries or communities so as to prioritize the needs for interventions in their country's water sector.

The GCVI results have demonstrated that five countries suffer from water scarcity, as well as socio-economic and political instability. They also suffer from the lack of access to their water resources, which in turn reduce their capacity to adapt to, and cope with, future impacts they may face as a result of climatic or governance changes.

The research has introduced the governance indicator to test the vulnerability of countries. It has attempted to show that vulnerability is influenced by both climatic changes as well as the performance of its government. The effectiveness of a government increases as it develops strategies and policies to efficiently and effectively manage water resources.

Implications and Recommendations

Effective water resources management can be achieved through the introduction of devices to conserve water in all sectors, the implementation of environmentally conscious policies, and the introduction of new water sources such as reuse of treated wastewater. Governments that implement these strategies and others are a reflection of a good adaptation and performances that are to be set up by good governances.

It is recommended to develop appropriate water resources management and to improve governments' environmental policies, including raising awareness on multiple levels. These strategies are expected to lead to decreased vulnerability to climatic changes.

GCVI index may combine a variety of other components; the inclusion of more variables that are relevant to the indicator may have more accurate and a wider reflection to the exact situation in the targeted country or community. The index can be applied on both country level and the national level of countries which can be done to focus on the vulnerable communities to draw policies for future planning and decision takings.

Multi- Criteria Decision Model for the Quantification of the Shared Water Resources Based on the International Water Law

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Executive Summary

Shared water resources are strong sources of conflict in the Jordan River basin shared by Israel, Jordan, Palestine, Syria and Lebanon. The control and allocation of water has been explicitly made a part of the ongoing peace negotiations. The thesis call for the application of international water law in the resolution of water disputes in the negotiating process. The challenging task for negotiators is to translate water law principles into operating rules and procedures for the equitable apportionment of waters from shared water resources. The negotiators need a decision tool based upon objective criteria or standards to reach equitable entitlements to shared water resources by all parties. The research introduces a multi-criteria decision tool as a possible approach to the problem of allocating the waters of the Jordan River between all riparian parties. The prime principle of the criteria is equitable allocation factors identified by water law. A general mathematical model is derived in which the proportional entitlements of the Jordan River basin waters are determined to the five riparian. It is hoped that, water negotiators review this approach.

Introduction

The conflict over water resources between Arab countries and Israel has always been a major reason for wars and bloodshed. Since the majority of the region's water resources are shared by more than one country, allocation and management of trans-boundary water resources assume great importance. Israel and Palestine share aquifers and thus need to agree on their water rights. In addition, Israelis and Palestinians (together with other riparian parties: Jordan,

Syria and Lebanon) need to reach accommodation regarding the Jordan River basin. International laws that regulate riparian rights are not much observed by Israel and there are no comprehensive agreements between all neighbouring countries, except the bilateral Jordanian-Israeli agreement signed in 1994 and the Interim agreement between Israel and Palestine, which clearly stated that water rights will be settled in the permanent status agreement. The multilateral peace talks aim at regional co-operation and bilateral negotiations between the parties. The water issue is addressed in both sets of negotiations.

Unless all states cooperate and jointly manage their shared water resources they both stand to lose in terms of the long-term viability of their water systems. The research provides an overview of current resolution principles and procedures, describes the characteristics and dynamics of water resources conflicts, and presents the conflict resolution process in theory. Moreover, it presents the application of those procedures and principles to the case study area and outlines one possible approach to the problem of allocating the waters of the Jordan River Basin between all riparian parties. The approach depends on the discussion of the principles of a comprehensive water-sharing regime drawn from the international law of trans-boundary waters.

Approaches and Results

Modern approaches to the management of international waters began in 1956 when the International Law Association (ILA) issued the Dubrovnik rules that, among many other things, stated that river basins should be treated as an integrated whole, regardless of national borders. A decade later in 1966, the association adopted what has come to be called “the Helsinki Rules” for rivers and lakes that cross or form borders but for which there is no formal agreement. The Helsinki Rules were further developed by the International Law Commission (ILC), an organisation created by the United Nations to focus on specific international legal issues. In 1991, the ILC completed the drafting and provisional adoption of 32 articles on the law of the Non-Navigational Uses of International Watercourses. Moreover, the United Nations General Assembly adopted a Convention on the Law of the Non-Navigational Uses of International Watercourses in May 1997. Among the general principles that help to reduce tensions and encourage effective and productive negotiations by the parties involved are: equitable allocation, obligation to resolve water related disputes peacefully, obligation not to cause harm to other riparian states and obligation to exchange hydrologic and other relevant data and information on a regular basis.

It has been often pointed out that the international water law is nonbinding and lacks enforcement mechanisms. This is true, but it may also be the “What we have got” as a guide for

negotiations. In some ways, the more challenging task for negotiators is to translate those principles into operating rules and procedures to determine the equitable apportionment of waters from shared water resources.

Equitable allocation of trans-boundary waters principle under international law is one of the most important developed by ILC and the Helsinki statements. The principle of equitable utilisation means that each basin state is entitled to a reasonable and equitable share in the beneficial use of shared water. "Equitable" does not mean equal use. Rather, it means that a large variety of factors, including population, hydrology, climate, existing uses, economic and social needs, geography, availability of alternative resources, and so on, must be considered in the allocation of water rights. It is to be noted that each factor is not to be considered in isolation, but looked at together with all the other factors, without any of them being given priority. This theory neither purports to identify fixed criteria in the sharing of international water, nor to protect existing water rights. Rather it aims at establishing a mechanism for cooperation and negotiation with a view to reaching an agreement.

This research translates the principle of equity in the use of a common property resource into a set of procedures to determine entitlements to the shared waters. The methodology is based upon the several factors listed above identified by the International Law Commission (ILC) in its draft articles on the non-navigational uses of international watercourses. For illustrative purposes, it is presented in terms of the water-sharing problem facing Israel, Jordan, Lebanon, Syria and Palestine in the Jordan River. The approach presents here should be seen as a first step in grappling with the problem of trans-boundary water resources rather than as the final word.

The equity factors are operationalized, yielding equity standards that will serve as benchmarks against which various possible allocation outcomes are measured. They are produced along with the operational definitions from which they were derived. An allocation outcome A (a,b,c,d,e) specifies the proportional shares of the Jordan River riparian, where a represents the Israeli, b the Jordanian, c the Lebanese, d the Syrian shares, and e the Palestinian shares. The sum of the five shares equal 100%. The nine equity standards used are derived from the operational definitions corresponding to the ILC factors.

A multi-criterion decision rule, based on the concept of error distance is used to determine the optimal allocation outcome. This concept defined the error distance as the absolute linear distance from a given allocation outcome to a particular equity standard. The optimum allocation outcome is the one that minimises the summation of the error distance measured outward

from itself to each equity point. The optimal allocation outcome A (17%, 21%, 9%, 33%, 20%) is calculated using an optimisation technique and represents the calculated entitlements for each country.

Conclusions

The scarcity of water in the Jordan River basin makes water allocation one of the central issues to be resolved in the Arab-Israeli conflict. In this basin, the international water law that regulate riparian rights are not well observed. This research call for the application of the international water law that can play a positive role in the resolution of water disputes in the negotiating process. The methodological approach presents in this research may be one way of approaching the problem of water allocations of the Jordan River basin and hopefully will provide some input into the negotiating process. It may be controversial and raise many objections; however, it is presented as food for thought.

Implications and Recommendations

The procedures describe in this research for determining the optimal allocation outcome used nine operational definitions of the ILC equity factors; clearly, these definitions are not exhaustive. One of the first tasks for negotiators, therefore, is to define and utilize such other factors as are deemed relevant to this particular water sharing problem. Assuming this methodology is adopted as a decision support tool in the context of the Middle East peace process negotiations, it would be up to the parties to decide which of the ILC equity factors are applicable to the Jordan River basin and to determine the appropriate utilization of these factors. They may reject any or all the equity standards used in this analysis, or include others not considered here.

Sharing water resources data is considered a basic tenet of water international law, yet accurate long-term data on shared and disputed water resources in the Jordan River basin are often restricted. This restriction must stop if any progress is to be made in resolving water disputes, and all water resources data should be immediately and fully released to all parties. Determination of an equitable allocation outcome must be seen as a dynamic process, taking into account new demands, changing resources, and water quality. It therefore called for exchange of relevant information and continuing negotiations over the exact allocation in any given year.

The satisfactory resolution of water disputes requires both improved conflict resolution methods and innovative measures such as water marketing and conservation. This combination of decision-making processes and technical or policy solutions is critically important to creating workable solutions to controversial water resource problems.

The Opportunity Cost of Drinking Water Quality Degradation in Ramallah and Al-Bireh Governorate

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Executive Summary

In the recent years, it has been observed that there is an increase of consumption of bottled drinking water in Palestine, mostly due to the perception that public drinking water is of low quality, unpleasant taste and lifestyle preferences. In addition, many households have installed water purification equipment to protect against inferior (real or perceived) public water quality. In the past 10 years mainly, the consumption of bottled water and the installation of home water purification apparatuses have noticeably increased in the Ramallah and Al-Bireh Governorate. This study is carried out to assess the quality of public drinking water in the Ramallah and Al-Bireh Governorate, and to estimate the averted expenditure on different drinking water to monetize the opportunity cost in 2009.

Introduction

Issues associated with drinking water have been stirring some attention in the environmental and economic fields as well as among regular consumers worldwide. Bottled water industries especially have seen increasing demands for their products in recent years. The world bottled-water market represents an annual volume of 89,000 million liters, and is estimated to be worth USD 22,000 million (Ferrier, 2001).

Palestinian consumers are drinking more bottled water every year, partly due to the fact that it is perceived as safer or of better quality than the public drinking water.

There seems to be many perceptions and some speculation regarding the public drinking water quality of the Ramallah and Al-Bireh Governorate. Collectively, hundreds or thousands of New Israeli Shekels (NIS) are being spent on drinking water, which includes public drinking water, purchased bottled water, and the costs incurred for the installation and maintenance of water purification apparatuses in the homes. If in fact the public drinking water is safe and healthy to drink, then this means that a significant amount of expenditure is being spent on bottled water and water purification apparatuses and thus represents a significant opportunity cost. In today's economy, the opportunity cost, or the value of what is foregone to have the next best alternative, is an important cost for the average consumer.

In the past ten years, the consumption of bottled water and the installation of home water purification apparatuses have noticeably increased in the Ramallah and Al-Bireh Governorate. In fact, the number of bottled water companies and water filter dealers has multiplied. The observable and sometimes intrusive marketing efforts of these industries are causing a stir among the local residents. People are troubled with the various allegations that their tap water is contaminated or unhealthy and are generally confused as to which drinking water is the healthier choice, causing them to expend more of their income on drinking water supplies. By shedding some light on the quality and cost of public water, in comparison to the quality and cost of bottled and filtered water, consumers will be able to make an educated decision about the type of water which is most suitable for them and their families. Additionally, the per capita water consumption in the Ramallah and Al-Bireh governorate has generally been calculated by dividing the total quantity of supplied water by the population. This estimate, though, does not take into consideration the amounts of bottled drinking water consumption into the equation, leaving a gap in this regard.

Approach and Results

Generally, it is found that the supplied public water in the Ramallah and Al-Bireh Governorate conforms to the Palestinian standards for safe and healthy drinking water. Bottled water consumption in 2009 is estimated at 58.3 liters per capita per year in the Ramallah and Al-Bireh Governorate. The total expenditure on bottled water in the Ramallah and Al-Bireh Governorate is found to be 23.25 million NIS in 2009, the total averted expenditure on bottled water is estimated to be 22.0 million NIS and the total expenditure on water purification apparatuses is found to be about 1.43 million NIS.

Thus, the total expenditure on drinking water totalled to 23.43 million NIS in 2009. When these expenditures are represented as the opportunity costs, the average person purchasing bottled water is forgoing the opportunity to save 400.94 NIS/yr, and the average person who has installed a water filter is forgoing the opportunity to save 74.74 NIS/yr, which are both costs associated with drinking water expenditures.

Conclusions

This research has shown that water pollution and possible contamination, or the perception thereof, of public drinking water has a cost to society. This information shows that despite the fact that water quality data, obtained from water providers, shows that there is no adverse health risks associated with the consumption of public drinking water, there remains to be perceived health risks among consumers and a significant amount of money is being spent on aversive actions such as the purchase of bottled water and installation of tap water filters.

Implications and Recommendations

It is apparent from this research that the general perception of public drinking water being of low quality is leading many consumers into expending a significant amount of money into purchasing what is thought to be 'better' drinking water. It is recommended that public water providers exert greater effort firstly into maintaining high drinking water quality in the distribution system of the governorate and secondly marketing this water to the general public to gain their trust and approval. This can be achieved by providing the public with accurate and concise annual water quality reports which can be easily accessed and comprehended by the average population and by providing a transparent monitoring system. It is also essential to raise awareness among the public on the importance of regular maintaining and cleaning of private roof and water tanks, checking household connections and fixing leaking or deteriorated pipes to ensure that the water being supplied to them is not being contaminated as it enters the home.

For residents who perceive a problem with their tap water, it is recommended that home tap water quality be tested by the proper authorities, such as the Palestinian Water Authority and Ministry of Health who will carry out a professional testing and will provide an un-biased assessment, based on which the consumer may make educated decisions regarding their choices on their choice of drink-

ing water. These actions can undoubtedly raise the level of trust among residents of the governorate and would eventually reduce their reliance on alternative, more costly, drinking water supplies. In today's economy, the opportunity cost for drinking water expenditures should be an important consideration and valuable concept to the average consumer.

For water monitoring institutions and regulators, the following recommendations are derived that are the labels of locally bottled and internationally imported bottled water must be monitored more closely to ensure that they conform to PSI bottled water standards (PSI 69-2005), the constituents of imported bottled water must be checked to make sure that this water is safe for human consumption. And bottled water must be monitored and analyzed regularly to ensure this it adheres to the claims made on the bottle labels.

More information is needed at the regulatory level regarding the industries and products dealing with drinking water, for both bottled water and filter industries, due to the high importance and apparent misconceptions regarding this issue.

Increase information exchange and coordination between the Palestinian Water Authority, water providers, Ministry of Health, Ministry of National Economy, among others, regarding the issues of public drinking water and the industries dealing with drinking water.

Development of Wastewater Treatment Tariff System: A Case Study of Al-Bireh Wastewater Treatment Plant



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Executive Summary

Urban wastewater treatment facilities in Palestine are still few in number and most of them are unsustainable. The old existing treatment plants are overloaded and the erection of newly ones is severely hampered due to political situations. Hence, developing an effective operational management and feasible cost recovery system are major elements behind achieving sustainable wastewater treatment facilities in Palestine. The evaluative framework developed for Al-Bireh sewage works tariff, the only one functional wastewater treatment facility, is comprehensive in approach yet additional features would enhance its usefulness as a policymaking tool.

The aim of this research study is to develop a feasible wastewater tariff system for the wastewater treatment plant [AWWTP] in Al-Bireh city as a case of study. To achieve this goal, data are collected from Al-Bireh municipality, AWWTP monthly operational reports and the German Agency for Technical Cooperation (GTZ). Excluding the capital expenditures [CAPEX], results for the year 2003 revealed that the specific treatment costs based on operational expenditures [OPEX] are about 0.25 \$/m³ compared with 0.49 \$/m³ including both CAPEX and OPEX. The study recommended six main price categories to calculate the actual incurred wastewater tariff. Collection of OPEX only is insufficient for treatment costs recovery, therefore, cost-effective and recovery tools should consider the polluter pays principles and the tax-beneficiary economy principles.

Any wastewater tariff system should opt for an integrated approach pertinent to operational management of sanitation services, including sewerage and stormwater networks as well as wastewater treatment and disposal infrastructures.

Introduction

The wastewater treatment sector is becoming more essential than ever, because of rapid population growth, urbanization, and water shortage in a developing country like Palestine. Urban municipal facilities in Palestine are still few in number and most of them are unsustainable. The old existing treatment plants, mainly oxidation ponds, are overloaded and the erection of newly ones is severely hampered due to political situations. Hence, developing an effective operational management and feasible cost recovery system are major elements behind achieving sustainable wastewater treatment facilities in Palestine. Al-Bireh sewage works, an extended aeration system established in 2000 is the only single functional wastewater treatment facility in Palestine. Whether the current collection and wastewater tariff systems are effective, is the research question of this study. Sustainable operation and compliance of effluent quality are governed by effective and efficient collection of annual treatment costs.

The aim of this research is to develop a feasible tariff system for wastewater treatment taking Al-Bireh wastewater treatment plant [AWWTP] as a case of study. The evaluative and assessment frameworks used to develop a wastewater tariff system for AWWTP, the only single functional wastewater treatment facility, is comprehensive in approach yet committed decision makers would enhance its effective enforcement.

Approaches and Results

To establish a wastewater treatment plant a fund of several millions of dollars is needed, so the project of wastewater treatment plant must be considered as an investment made by the local authority, and the charge that polluters pay for treatment is the revenue of this investment. Hence, in order to have a successful investment, the present value revenues for the duration of the project must cover the present value of all costs of the project in addition to a normal return.

The main objective envisaged was achieved through the following methodology are comprehensive data collection from Al-Bireh municipality and the German Agency

for Technical Cooperation [GTZ]. Data collection and analysis of monthly reports for the self-monitoring of Al-Bireh sewage works including all relevant operational parameters [e.g. daily septage flow rate in every month of the year, daily and weekly working hours for every unit of the plant, electrical power demand, spare parts needed, chemicals consumed etc..] in order to calculate the annual running costs of the treatment plant.

Results obtained from data analysis for the year 2003 showed that the calculated annual operational expenditures are 428,580 US\$; yielding an annual specific costs of 8.57 US\$/PE or 0.25 \$/m³ wastewater treated. Including the annual capital expenditure in the present tariff would lead to new actual annual capital and operational costs of about 835,430 US\$. Finally, the annual CAPEX and OPEX for the wastewater collection and transport including pump stations are not incorporated in the specific treatment costs and need further investigation.

Conclusions

Based on the results obtained the following conclusions are drawn that are partial collection of the operational expenditures will not lead to operational sustainability of AWWTP. A cost-effective wastewater tariff must include both CAPEX and OPEX.

Annual operation, maintenance, and repair for all unit operations of AWWTP can only be attained by a feasible wastewater tariff system, which is practical and affordable for the customers.

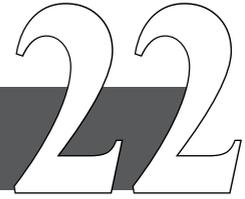
Finally, capital investments are necessary but collection of OPEX is crucial for a full cost recovery of any WWT facility, donor countries are not responsible for OPEX issues.

Implications and Recommendations

Sustainable management including effective operation of wastewater treatment facilities are crucial for public health and environmental protection. Operational sustainability of sanitation services can only be achieved by develop and efficient and effective cost recovery system aimed at full cost coverage including all aspects of wastewater management [collection, transport, treatment and disposal] in Palestinian communities. Moreover, full cost recovery entailed committed municipal man-

agement and ability to enforce tariff systems considering clients willingness to pay and affordability and top management levels including the mayor, municipality chief engineer and the relative governmental institutions should cooperate closely to enforce the tariff system and perform institutional reforms, if needed.

Additionally, the potential revenue from agricultural production through reclaimed water uses, as well as the aesthetic or recreational value of a particular alternative should be further investigated.



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Executive Summary

Palestine, as part of mid-eastern counties suffers from limited and vulnerable water resources. A high degree of management needed to ensure that water is protected and efficiently used. Increasing attention is being given these days to educate children and youth on water related topics through water conservation campaigns. Education can help rise the next generation with knowledge and attitudes that promote the wise use of water. The main objective of this thesis is to choose appropriate education techniques and resources for best water management programs, through evaluating the water and environmental material.

Moreover to create a long term water efficiency ethics and to promote public awareness issues at the level of individual users. A book about water is used as educational material for 270 students who are involved in this study. A pre and post study questionnaire is used to assess the cognitive effectiveness of the educational material on the knowledge, attitude and practice of the involved students. The results of the study show that an improvement is shown to all KAP variables (knowledge, attitude and practice) after one study year. Water education, using water book successfully and significantly affected the knowledge, attitude and practice of students by the end of study year. Moreover results achieve regarding correlation between three variables is significant, when the knowledge of the students increased so their attitude toward water saving became more positive, and easily move to action. Finally it could be said that we need to introduce water education to school curriculum in Palestine which considered as part of solving our water shortage problem.

Introduction

The unique historical water situation in Palestine remains one of the most controversial that needs resolution. Water crisis is not only a consequence of water scarcity in the region, but also an inherent part of the general Palestinian – Israeli conflict. Water resources management is becoming an increasingly important issue for policy makers. However, without changes in the way consumers use water safe, wise and ecologically sustainable, water resources management is impossible.

People believe that they can do nothing to solve the problem since it's a pure political issue, but actually finding ways to conserve water is vitally important for preserving a decent quality of life, and for protecting the natural water resources. Everyone can act to help starting with a very simple step like turning of the tap. When a student at the school open the water tap to drink and keep it open so can we imagine the amount of water wasted in such action taking in consideration that students form a large sector of our society? Can we calculate the amount of water we conserve and safe if we educate students to promote the wise use of water?

Involving the educational sector provides great opportunities, since it is an existing system already focused on learning. A comprehensive school program targeting school children where they learn about water conservation can move schoolchildren from ignorance to awareness, interest and action.

The main objective of this thesis is to choose appropriate education techniques and resources for best water management programs, to create long-term water efficiency ethics and to promote public awareness issues at the level of individual users through evaluating the water and environmental material. Moreover to create a long term water efficiency ethics and to promote public awareness issues at the level of individual users, that will move water users from a position of wasting water to one using it efficiently.

Approaches and Results

A pre and post study questionnaire consists of 30 questions is used to assess the cognitive effectiveness of the educational material on the knowledge, attitude and practice (KAP) of the involved students. The educational material is a book published by the Public Awareness and Water Conservation project. 270 students from three dif-

ferent schools – private, governmental and UN - are involved in the study. The book is supported by different activities like site visits, water campaigns...etc. The book is used for one sclerotic year, one hour per a week.

The aim of the pre test is to provide the baseline data on the three variables (KAP) while the main aim of the post test is to show what extent and how water education affected the target group through changing their knowledge, attitude and practice.

The effectiveness of the approach is demonstrated by measuring three variables knowledge, attitude and practice. T-Test is used in order to assess the degree of statistical associations between the pre and post test results for each variable. Correlations between the three variables are tested. It is noteworthy that significant improvement in all KAP variables is achieved. The water education text, as used, considered some principle to inform and motivate students to take actions. These principles includes clear educational goals related to student community, water issues, activities and materials that support written material and match students educational needs with desire.

Evaluation of the impact of one year study and the results of the study show that an improvement is shown to all KAP variables after one study year. Water education, using water book successfully and with some support activities significantly affected the knowledge, attitude and practice of study.

Conclusions

Results of pre-post study indicate that a special effort should be made with regard to Palestinian schools environment that can support and help the students in adopting environmental lifestyle and ethics. The main achievement is that water education succeeded to influence the students' knowledge, attitude and practice to a different extent. Consequently, an improvement is shown in all KAP variables leads to conclude that water education should be recognized as a pertinent, integral part of daily life in our schools.

Implications and Recommendations

Water education should be introduced to school curriculum through all grades which can be considered as part of solving our water shortage problem. Children often lack

their elder's prejudices and value system, they learn quickly and easily spreading knowledge among their peers, they are the primary recipient of formal education.

Developing a new Palestinian curriculum based on water issue that combine indigenous knowledge with school based learning, is needed. The curriculum can be used by different ages with new approach of active learning methodology. Teachers, the central and main part of water education must be trained and supported. It's important to involve parents, peers and community to be sure that our students maintain and reassess water conservation practices over time.

Students who are given the opportunity to engage in long-term realistic environmental issues tend to demonstrate responsible environmental behavior. The program planner must take into consideration the need to educate students to develop long term commitment. Schools need to re-evaluate how and what they are teaching and how to better prepare students for various environmental education. In order to take action, our students must believe in their ability to bring about change through personal behavior, change that accompanied by individual sense of responsibility.



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