EasyChair Preprint

№ 653

Environmental, Social and Economical Influences on Applying Waste Water Treatment Plants in Khartoum (Al Riyadh City-Case study)

Abdul Rahim Mohemed Elhassan and Mojahid Eldouma

November 29, 2018

Environmental, Social and Economical Influences on Applying Waste Water Treatment Plants in Khartoum Cities (Al Riyadh City - Case Study)

Abdel Rahim M. El Hassan(1)Mojahid Eddoma(2)

(1)Department of Civil Engineering, college of Engineering & Architecture, Al Mughtaribeen University. alhassans50@hotmail.com.

(2) Department of Civil Engineering, college of Engineering & Architecture, Al Mughtaribeen University mujahidouma@gmail.com.

المستخلص:

تعتبر الهندسة البيئية سلاح مهم في محاربة الأمراض. هنالك عدة تحسينات في صحة البيئة في الدول النامية خلال القرن الماضي تعزى إلى مهندس صحة البيئة أكثر من الأطباء، لكن هذه التحسينات لم تطل الدول الفقيرة والتي ما زالت تعاني من الوفيات، الامراض والاعاقة الجسدية التي دائماً تكون في المناطق الفقيرة.

الهدف الرئيسي من هذه الورقة هو تطوير مفهوم للمتطلبات الرئيسية لإنشاء محطات معالجة فعالة وإنشاء شبكات صرف صحي بالعاصمة الخرطوم، للوصول لذلك الهدف تم اجراء دراسات ميدانية بمدينة الرياض (كدراسة حالة) من حيث عدد السكان وكمية المياه المستهلكة وطبيعة الارض.

هذه الدراسة أثبتت أن إنشاء نظم معالجة مياه الصرف الصحي سيؤدي إلى تحسين الوضع الصحي والبيئي وكذلك تحسين مستوى الحياة بالنسبة للمجتمع.

Abstract :

Environmental health engineering is an important weapon in the fight against disease. Many of the dramatic improvements in public health in the developing countries over the last century or so are attributable to public health engineers, at least as much as to doctors. But these improvements have yet to reach the vast majority of the world's poor, who still endure the high rate of death, disease and disability which have always been associated with poverty.

The main aim of this paper is to develop an understanding of the main requirements for the effective development of water treatment systems in Khartoum cities.

To achieve this aim, the methodologies used are field study in Riyadh city (as a case study) regarding the population, water consumption rate, soil topography.

The results of these field studies showed that application of waste water treatment plants will improve the environmental health and human life style.

Keywords : Environmental Health, Contamination, waste water treatment, life style

1. Introduction:

In modern societies proper management of waste water is a necessity, not an option.

It has become increasingly apparent in recent years that the effects of poverty (death, disease and disability) may be alleviated without substantial increase in a countries per capita income (People's Republic of China and Serilanka) were although the per capita income remains low, such indices of the quality of human life as the infant mortality, life expectancy and rates of infection with certain parasites, have improved significantly [1].

In this paper, the researcher/s provided studies showing that the utilization of waste water treatment plants will improve the public health of the society life style.

1.1 Aims and objectives:

(i)Development of an understanding of the main requirements for the effective development of water treatment plants in Khartoum.

From the field investigation, it is known that the absence of waste water treatment systems in Khartoum causes the pollution of the underground water aquifer and this affects the citizens socially environmentally and healthy. There is much need for the implementation of more positive programs in the field of social development in providing efficient waste water treatment systems in Khartoum towns.

(ii)Identification of the factors defining the main contributors to the effective development of the sanitary system in Khartoum.

From the qualitative analysis the paper conducted that if the local authorities and decision makers in Khartoum district awarded contracts to specially comprises in this field by BOOT system, then the city will be without environmental diseases and a clean city, the culture and the appearance of the citizens will be more attractive and lifestyle will be upgraded.

2. Water pollution:

Water can be exposed to various types of pollution. An example of this is organic nitrogen contamination resulting from human intervention, such as civil sanitation in the aquifers in the cities and large villages within Khartoum State which has more than 700,000 siphons and drain wells that can pose a threat to public health, other research has showed that 80% of the diseases can be directly related to water and in addition, polluted drinking water is the major cause behind high rates of kidney failure [2].

2.1 Pollution in groundwater in Khartoum:

A study has been conducted in Khartoum State on sanitation and environmental pollution and its effect within the state. The initial report was on groundwater contamination because of the presence of water drainage wells and septic tanks in some areas of Khartoum. The results showed that there is chemical contamination of the groundwater and that the amount of pollution increases overtime. The second study was on re-use of drainage water area within the Green Belt in south Khartoum. The result showed that the presence of heavy metal accumulation: chrome, copper and zinc in the soil, surface water and groundwater, which in some areas increased the pollution in the water of the Nile estuaries to varying degrees, especially in summer when the water levels of the Nile River are at their lowest [3]. The study confirmed that the sources of groundwater and surface water in Khartoum State are vulnerable to contamination by the existing sanitation, which must find a quick fix by the competent authorities.

Household waste is discharged into the tank through a number of manholes and allowed to settle in the water until the fermentation and digestion processes have taken place and the organic substance are emulsified and carried away by the natural movement of the groundwater.

The danger of groundwater contamination by sewage relates to the high amounts of organic matter and minerals found in both liquid and solid effluents from domestic and livestock sources. Organic compounds such as phenol may form offensive as well as toxic compounds when combined with chlorine and can be carcinogenic [4].

Water analysis for a number of groundwater wells have proved the existence of two types of chemicals: the first one is a high percentage of nitrate (more than the limit allowed by the World Health Organization) which leads to sudden death in children, and the second is microbial which can lead to an increase in the number of bacteria in the colon. These chemicals came from siphons within drainage wells, and by tracing this through analysis proved leakage from siphoned wells to the underground water [5].

Studies confirm the movement of contaminants to a depth of 200 meters underground. There is a study of contamination of groundwater in the Khartoum State, funded by UNESCO that brought together a number of experts who used a mathematical model able to predict via the available variables what the threat of contamination was likely to be to the groundwater studied.

It was proven by the study that there are areas of high vulnerability to contamination due to the hydrological properties of the reservoir itself [6]

3. Waste water quality:

Any community which has a water-borne sewerage system will produce a flow of waste water and excreta, generally known as sewage. The sewage may be of domestic, industrial or agricultural origin of typically, a combination of these.

The composition of sewage is both complex and variable a typical composition is shown in Figure (1). The most fundamental characteristics of a sewage are its suspended solids, its oxygen demand and it content of pathogenic organisms and toxic chemicals.

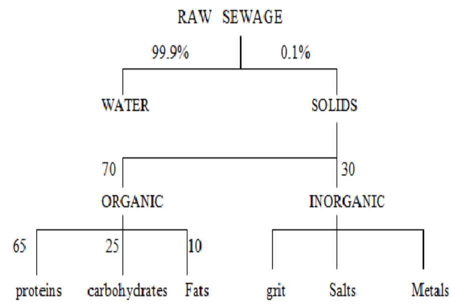

Figure (1): The composition of sewage source: from Tebbutt (1992)

4. Urban sanitation:

A major challenge facing those concerned with environmental health in developing countries is that of excreta and refuses disposal systems appropriate to high-density, low income communities.

The sanitation system which is by far the most convenient to the user is the conventional water-borne sewerage system found in most European communities. However, there are several reasons why a water-borne sanitation system is inappropriate for most high-density communities in developing countries.

Cost: The water-borne system is the most expensive of all sanitation systems and has a very high capital construction cost. The cost of laying the sewers alone may be as high as US$ 1300/person [7].

The paper propose the BOOT (Build Own Operate & Transfer) system for the waste water treatment plants project in which an expert entity to receive a concession from the public sector (Khartoum Authority) to finance design, construct, own and operate the project. This enables the project proponent to recover its investment, operating and maintenance expenses in the project.

The government will charge the citizens for sewage drainage service, the payment will be charged with water bill.

Water use: Water-borne systems use large volumes of drinking water merely to transport waste along pipe-water which has to be expensively treated before being released back into the hydrological cycle.

Construction: Water-borne sewerage is a complex technology requiring careful and skill construction if it is to operate smoothly.

Sewer-laying: By and large, sewers must be laid in straight lines. To dig trenches in straight lines through squatter settlements necessitates the demolition of a substantial number of houses, which is often be politically and socially unacceptable.

Blockage: Conventional water-borne systems are prone to blockage if large objects are fed into them, or if inadequate water is available for flushing.

4.1 Planning a sanitation program:

Sanitation program here is the mean of improvement of waste water treatment systems , there are certain key elements which a sanitation programme should include:

(i) a central steering committee comprising the ministries or departments responsible for finance and planning, health, urban or rural development, water supply and sewerage;

(ii) sound project management, site investigations, careful technology choice and design;

(iii) pre-programme study of social factors, economic constraints and beneficiary preference;

(iv) development of an extension system, including health holders, and feedback from the community;

(v) access to and delivery of building materials and mass-produced components (Figure 2), combined with financing mechanisms.

(vi) integration of designs with infrastructure development, particularly water supply, storm water drainage and housing layouts;

(vii) integration of programme management with existing administrative structures, such as village or town councils.

(viii) a monitoring and evaluation programme;

(ix) a programme for briefing central government personnel, and for training engineers, technicians, artisans and extension workers.

4.2 Choice of system:

The selection of one design over another is determined by a composite of technical, socials and economic factors. Some of these factors are illustrated in Table (1).

Figure (2) illustrates how the technical, social and economic checks may be coordinated in practice

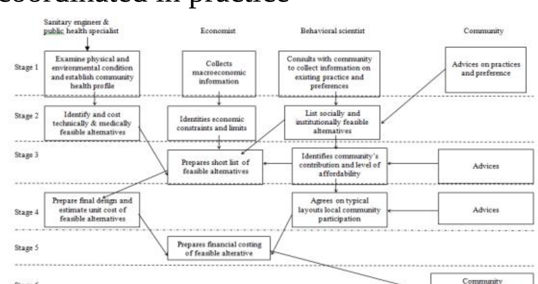

Figure (2) Recommended structure for feasibility studies for a sanitation programme.
Source from Kolbemotten *et al.* (1982)

Table (1): Composition of several types of sanitation system.

Sanitation system	Rural application	Urban application	Construction cost	Operating cost	Ease of construction	Water requirement	Soil condition required
Pit latrines	Suitable	Not in high density areas	Low	Low	Very easy except in wet or rocky ground	None	Stable permeable soil; water table >1m deep
Pour-flush toilets	Suitable	Not in high-density area	Medium	Low	Requires builder	Water near toilet	Permeable soil; water table 1m deep
Sewered pour-flush toilets	Not suitable	Suitable	High	Medium	Requires engineer	Water piped to house	Preferably stable soil; no rock
Vault toilets and vacuum truck	Not suitable	Suitable where vehicle access & maintenance available	Medium	Very high	Requires builder	None	None
Septic tanks and soak aways	Suitable	Suitable in low-density areas	High	High	Requires builder	Water piped to toilet	Permeable soil; water table >1m deep
Conventional sewerage	Not suitable	Suitable where affordable	Very high	High	Require engineer	Water piped to toilet	Preferably stable soil; no rock

4.3. Waste water treatment system cost:

It has been pointed out in item 4 (urban sanitation cost) that whether or not a loan is obtained to finance a sanitation programme, the community must eventually pay for it, and it must therefore be affordable. There are limits to how far sanitation for the poor can be subsidized by the rich, though this is possible to a certain extent through progressive charging systems. To the extent that users will be expected to pay all or part of the cost, therefore, it is important to know how much they can pay.

The calculation of costs can be done in two different ways, to derive economic and financial costing respectively.

4.3.1 Economic costs:

Economic costing is used by national planners and policy-makers to make a least-cost comparison between alternatives and includes all costs to the economy regardless of who incurs them, but does not include taxes and eliminates price distortions created by financial legislation.

The wide variation in costs between different systems is illustrated by the results of a survey conducted by the World Bank in several developing countries, which found that the mean annual economic costs per household of various sanitation technologies, relative to conventional sewerage (US$), were as follows [7] :

improved pit latrines	10
pour-flush toilets	10
sewered pour-flush-toilets	40
vault toilets	50
conventional septic tanks	90
conventional sewerage	100

These figures should not, however, be applied to specific settings; the costs of the various options must be calculated afresh for each specific context (in this paper the researchers calculated the cost Of the system for the plan-city shown in Fig. (3) for Al Riyadh city – Khartoum after considering many alternatives).

4.3.2 Financial costs:

Economic cost comparisons are not normally used for choosing the technology to be used in specific sanitation programmes, as the costs are in practice usually borne by penurious local authorities and by the beneficiary households.

4.4 Operation and maintenance:

In the same way as for the construction of excreta disposal facilities, thought must be given to the division of responsibilities between the sanitation agency and the users with regard to their maintenance.

Fig (3): AL Riyadh city blocks
By: Ministry of urban planning – surveying department .

4.5 Method of data analysis:
The data concerning the design of the system of waste water treatment plant in addition to the sewer pipe network to transport the waste to the plant (the population of Al Riyadh city, the type and topography of soil (Fig. 3), the water consumption rate), this data is collected from Khartoum locality, Ministry of Minerals, Building Research Centre, Ministry of Urban Planning – Surveying general department .

The data interred the software (sewer CAD) the data output shown in Table (2). The pipes diameters and the velocity of the sewage are found to be reasonable to carry the daily waste water rate of 750 m^3/d (Table 2). The population growth from 19,000 to 88,000 persons for design period of 35 years.

Table (2) – the critical values of design (diameter, flow, and velocity)

	Velocity m/s	**Flow L/s**	**Diameter .mm**
Max	4.28	8611.11	2100
Aver	3.84	566.66	750
Min	0.68	25	250

Activated sludge system:
The decentralized waste water treatment plant to be used should contain the following compartments:

- Screens with comminutor devices.
- (3m x 3m x 3.5m)
- Grit removal channel.
- Aerator tank with Blowers 3 x 4.5 x 3.5m with control room for blowers.
- Three blowers to add 2mg/L (Dissolved oxygen)
- Clarifier tank (3 x 3 x 3.5m)

The capacity of the water treatment lant is 4000 m^3/d. The effluent BOD = 15-20 mg/L. the effluent S.S.< 20mg/L.

The cost of this system (plant and sewer network) is approximately 114,400,000 $, this amount could be paid by investor(s) to construct the system by BOOT system for 7 years period.

The bill of the waste water system will be collected from the citizens on monthly basis in addition to advance payment from the person to inter the service.

5.Conclusion and Recommendations:

The paper has achieved its aims as follows:

After an investigation of the waste water system in Khartoum generally and Al Riyadh city specially and after evaluation of the situation through the methods and mechanism of data collection and data analysis, the paper concluded the following:

Diseases in Sudan are directly related to water and waste water discharge, so the improvement of the waste water system in Khartoum would greatly reduce these diseases and, accordingly, this will produce a healthy environment.

* The Khartoum underground water is exposed to pollution due to civil sanitation in the high free aquifers in the cities and large villages included within Khartoum State. Accordingly, it is necessary to construct a sewer system networks to collect sewage from homes so it can be treated in treatment plants and then this treated water could be taken and used for landscaping purposes.

* The waste water discharge tariff should be included in the water supply tariff for the area of the system.

* Reduction in the cost of operating building, in the operation and maintenance of water and sanitation facilities and an improvement in the level of service and billing will be achieved by introducing a strong and transparent regulatory framework.

5.1 Recommendations for the improvement of the waste water in Khartoum:

Based on the findings of this paper, the following recommendations is proposed to improve the wastewater system in Khartoum and, accordingly these will also improve the social, economical and environmental wellbeing of the Khartoum citizen.

- Raise awareness of the importance of waste water treatment systems and intensify awareness-raising through the media.
- Conduct research and seminars on the waste water; in order to find solution and exchange research results.
- Seek to provide the necessary funding through international and regional institutions in order to benefit from waste water excreta technologies and development of waste water treatment processes.

* Foundation of joint committees in the State of Khartoum between the Water and Wastewater Authority, Khartoum, the General Administration of Roads and the National Authority for Electricity to avoid the causes of damage roads, resulting in broken pipes and water lines.

* Investors are needed to invest in the construction of waste water treatment technologies.

References:

[1] Peavy, Heward, S; Rowe, Donald, R. and Tchobanoglous, G. (1985). '*Environ-mental engineering*' ISBN 0-07-100231-6.

[2] Elhassan, A.M. (2011). '*Rehabilitation of the urban water system in Khartoum*' Ph.D Thesis, University of Salferd.

[3] Ismail, F. (2008). '*Polluted water: new danger threatens the healt'*, Al Sahafa news paper No. 5297, 18.03.2008.

[4] Langer, M. (1989). '*Engineering geology and waste disposa*l', scientific report and recommendations of the IAEG commission INT Assoc. Eng Eogl Bull, 51: 8-12.

[5] Abdullah, T (2008). '*Polluted water: new danger threatens the health'*, Al Sahafa Newspaper No. 5297, 18.03.2008.

[6] Murtada,J. (2008). '*Contaminated water: new danger threatens the health'*, Al Safaha news paper No. 5297, 18.03.2008.

[7] Cairncross, S. and Feachem, R. (1983). '*Environmental health engineering in the tropics: an introductory text'* . 2nd Ed., ISBN 07471 938858.