Journal of Engineering Sciences, Assiut University, Vol. 37, No. 5, pp. 1049-1062, September 2009.

METHODOLOGY OF PLANNING DOMESTIC SEWAGE SYSTEM IN SLUMS & RURAL AREAS BY ECONOMIC WAY

Ezzat Abd Elshafy*, M. Reda Haggag**, and A. Saad Abousrea***

**Prof . of Sanitary and Environmental Engineering Faculty of engineering Cairo University*

*** Prof .of Planning environment & infrastructure Faculty of Urban& Regional planning Cairo University (redahaggag@hotmail.com)*

**** Senior eng in water& sewage department in General organization for Physical planning (ahmed_mema@yahoo.com)*

(*Received July 16, 2009 Accepted August 9, 2009*)

Slums and rural areas became one of the most serious problems which face Egyptian society whereas 57% from Egypt' population live in Egyptian countryside, and 20% in slums (human development report), less than 5% only from Egyptian countryside with sanitary sewage service (CAPMAS). The problem has economic, physical, strategic, social and environmental dimensions, legislations and laws. The paper aims to provide immediate flexible system' suggestion to adhere to those dimensions. It took successful international and local experiments related to the problem. It took a village as case study; it took samples from desludging truck in the village and analyzed it. Analyzing results and comparing it with the results of analyzing at the influent of traditional WWTP (ZENIN). The study ended into proposing Simi non-pipe system which consisting of main collector to receive discharge from trucks as an immediate stage and then treatment plant working with anaerobic system (UASB/USBR) it will followed by aerobic-system later and final disposal dumping into drain.

KEYWORDS: *Planning, Slums , Rural Areas, Low Cost Sanitation, Anaerobic system, UASB, RBC, USBR*

1. INTRODUCTION

The strength of wastewater from the treatment point of view is dependent on the value of the chemical oxygen demand (COD mgl/l) of the wastewater (Fergala 1995).

In past 20 years different types of anaerobic systems have been developed and put into operation. They decompose organic matter in the absence of molecular oxygen. Below are the figures of common anaerobic digesters. Among various anaerobic reactors, UASB is the most widely studied upon and applied in the real scale. UASB is considered superior because of its simplicity in construction, maintenance and operation. UASB reactor was first designed to treat industrial wastewater which is considered strong in nature with COD value as high as 100000 mg/l.

Using the UASB reactor, as a new technology is suitable for the small rural villages suffering from the problem of absence of sanitation projects especially it needs no complicated technology, (Ehab Ruzzik 2004, PhD Thesis) From the previous comparison between aerobic and anaerobic treatment process it is clear that the anaerobic treatment of sewage offers significant advantages over aerobic treatment. However, the intrinsically favorable stoichiometry of anaerobic treatment alone will make it an adequate alternative for the removal of organic matte from sewage.Basically, two other factors are also important (Adrianus C. van Haandel and GatzeLettinga 1994).

Reasons of using UASB reactor in the full scale are its simplicity and its inexpensive construction cost compared to the mentioned high rate reactors with its ability to retain very high amount of highly quality biomass which meaning more organic space loads and better safety against shock loads (Sabry 1999).

Appropriate sewage treatment technology by a combination of UASB and DHS (down flow hanging sponge) reactor was continuously evaluated. Removal efficiency of over 95% for total BOD, 80% for COD and 75% for SS, from the raw sewage. The system produced an excellent effluent quality with only 4-9 mg/l of residual total BOD. (Madan tandukar; izarul Machdar ; shigeki uemura; akiyoshi; and hideki harada), Japan.

A low-cost municipal sewage treatment system with a combination of UASB AND The "fourth generation" down flow hanging sponge (DHS) reactors . The whole system was operated at a total hydraulic retention time (HRT) of 8h (UASB: 6h & DHS:2h) for a period of over 600 days. The remove 96% of unfiltered BOD with only 9 mg/l remaining.M. Tandukar, S.Uemura, I.Machdar, A.Ohashi, H.Harada), 2005 Japan.

Anaerobic digestion, like other biological processes, strongly depend on temperature the influence of temperature on the rate and extent of anaerobic digestion has been the subject of many investigations (Henzen and Harremoes 1983).

The main objective if the sewage treatment is to correct the characteristics of sewage in such a manner that the use or final disposal of the treated effluent can take place in accordance with the rules set by legislative bodies without causing an adverse impact on the ecosystem of the receiving body. (van haandel and Gatze lettinga, 1994).

2. AIM OF PAPER

The paper aim to suggest a quick and suitable solution, for sewage system in slums & rural areas taking into consideration dimensions of: economic, physical, strategic, social, environmental, legislations and laws.

3. PROBLEM DIMENTION

1-Economic Dimension: Budget required for the service of such areas is about 200 billion whereas 20 billion are allocated in the six five-year plan 6.5 in the first year.
2- Urban Dimension: narrow streets and bad condition of the buildings which gets it difficult to supply the areas with the sewage system.
3-National strategic dimension: The supply of sewage system to such areas would increase land values therefore increase the agrarian land corrosion, another strategic dimension that includes the supply of such areas with the sewage service increased water consumption by percentage of 35%(GTZ in "Al Mufty") whereas Egypt’s share of the river Nile is fixed in spite of the overpopulation and urban development.

4- Social dimension: The vast majority of the population of these areas does not have environmental awareness.

5-Environmental dimension: The negative environmental effects that result from the lack of sewage service, desludging of the trench drainage and throwing it in canals and drains, the farmers are forced to use them under the conditions of rare water in the canals, which causes the spread of direct diseases (water born diseases) and the high level of underground water.

6 -legislation and laws: Throwing of effluent wastes after treatment in the drains such as (law 48 and law4) this requires a very large budget to meet this specification.

4. PREVIOUS CASE STUDY

4.1 (International Case Studies)

4.1.1 Japan Case Study: (Excreta treatment plant in Kobokawa city),Sewerage works= 3-4 times Cost than N.S .This treatment plant treat excreta collected from three municipalities (Kobokawa, Taicho and Towa village);Started operation in 1978,Feces and urines are collected using vacuum truck; Treating human excreta in high concentration. Population served 22000 capita. Capacity 35 m^3/day.

4.1.2 Latin American (Natal in Brazil): A non-conventional sewerage system Simplified sewerage is a collective sanitation scheme used to remove excreta and household wastewater. This technology was first developed in Brazil—where it is also known as condominial sewerage, In order to reduce costs, the system is designed to be laid in sidewalks, back or front yards, (Source: Mara, 2000).

4.1.3 Orangi, Karachi City, Pakistan: Orangi Pilot Project provided technical advice and plans for a simplified design, which reduced the cost by almost a factor of 10, but the organization did not contribute one rupee for construction. Each family invested about a month's income to buy materials and hire labor. The city has plans to build a treatment plant.

4.1.4 Indian case study: This experiment deals with the pollution of the Yamuna river in India whether by throwing the human solid wastes or liquid wastes of drainage on the river directly without treatment and therefore taking the sample from the river to identify its pollution through the comparison of the results to the standard specifications and the treatment plants along the Yamuna river at the sources of pollution to treat the household drainage like the establishment of plant operated by the an aerated system and followed by aerated system like the Kanpour Plant,36 MLD UASB Reactor at Kanpur followed by aerobic system (down flow hanging sponge).

4.2 Previous Case Study: National Case Studies.

NOPWASD formed a committee for studying all possible options for low cost systems and based on the study's findings, decided to rely upon two techniques: the (RBC): Rotating Biological Contractor, and (UASB): Upflow Anearobic Sludge Blanket systems. AUASB system of 3000 m3/d was constructed in one village. The design and implementation of the systems was carried out in a way to ensure minimum cost while utilizing local manufacturing capabilities and capacities. Additionally, one RBC system of 3000 m3/d capacity was constructed. The RBC system was applied in Fisha -

Sleem village, Garbia Governorate and UASB system was applied in Nahtay village, Garbia Governorate.

Above all, these experiences show that there is no silver bullet –there is not one single technology with the potential to solve all problems in every context. Sanitation solutions must be locally relevant and acceptable to those who will use and maintain all elements of a sanitation system - from toilet, to removal and transportation, to treatment and to use of products as potential agricultural inputs.

5. REASONS FOR SELECTING THE VILLAGE

The village was selected because it represents the sector required for the study, which is the agricultural sector on which the buildings were extended randomly, and this village is not served by sewerage system. In addition, its roads are narrow and bumpy, and have now pyramidal grading (delta sector) and the current situation of sewage there like other villages of the nations. Finally it represents slums & rural areas.

5.1 Sampling

The samples were taken from the trucks before emptying its loading in the canals and drains for the following reasons:

1. Nature of the liquid wastes is not traditional like the sewage collected through the traditional sewage networks.
2. Taking samples as an indicator to identify the organic load.
3. There trenches in front of or inside the buildings to filter the domestic sewage in the land, which increases the organic load.
4. Prohibition of throwing the desludging in the canals and drains for such an action from ministry of irrigation and ministry of housing, so the samples were not taken to identify the concentration of the organic load.
5. To give an image that helps when choosing a suitable system.

5.2 Result

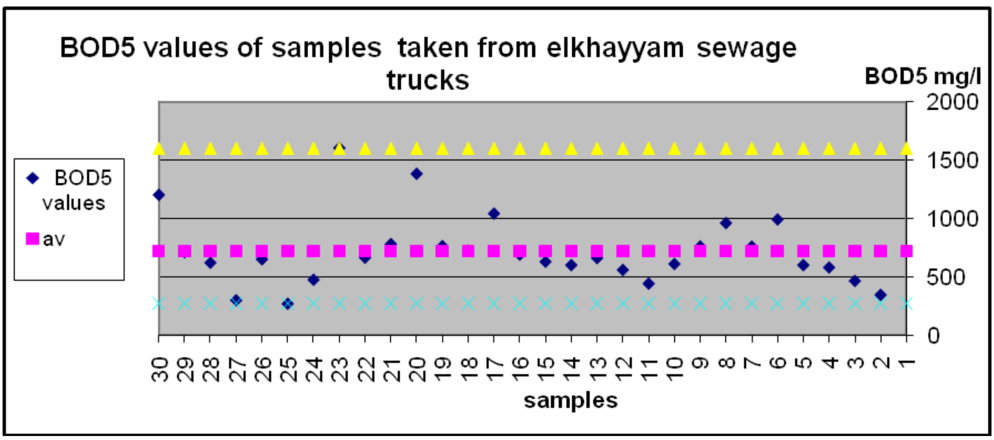

Fig No (1)

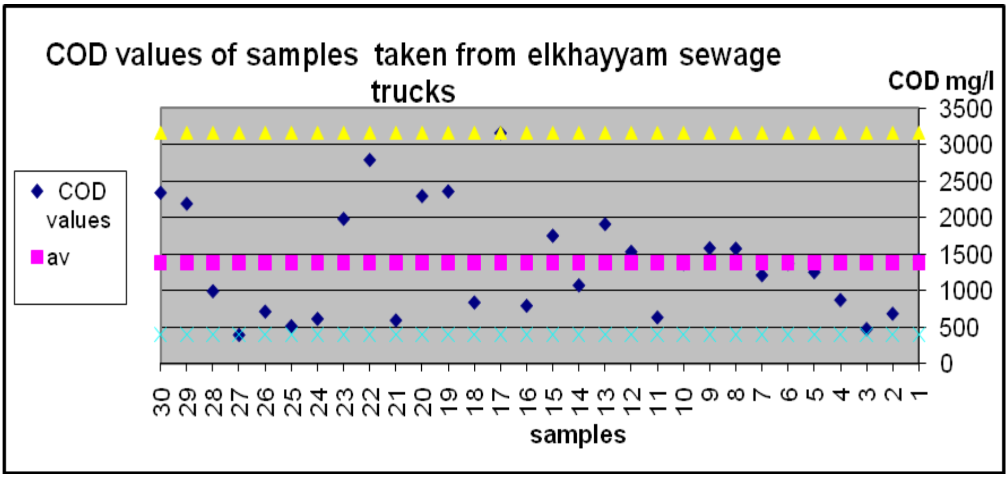

Fig No (2)

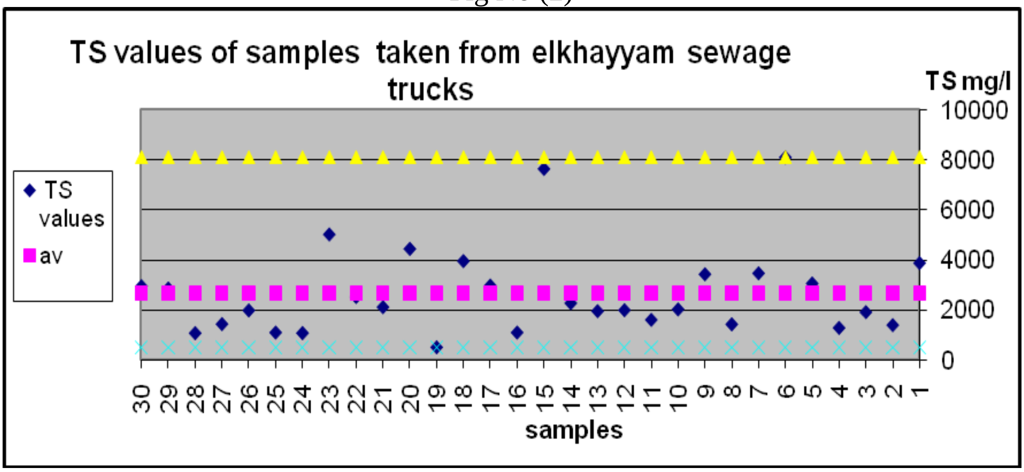

Fig No (3)

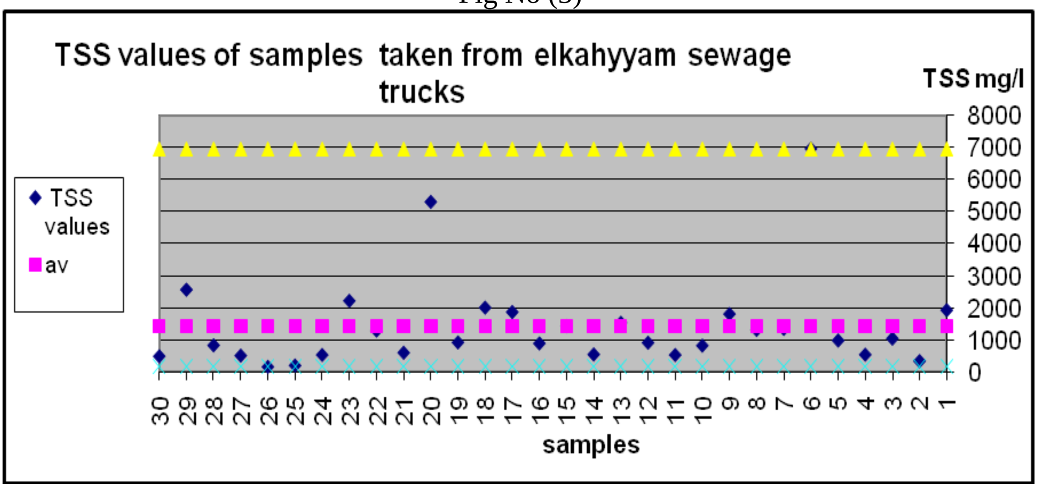

Fig No (4)

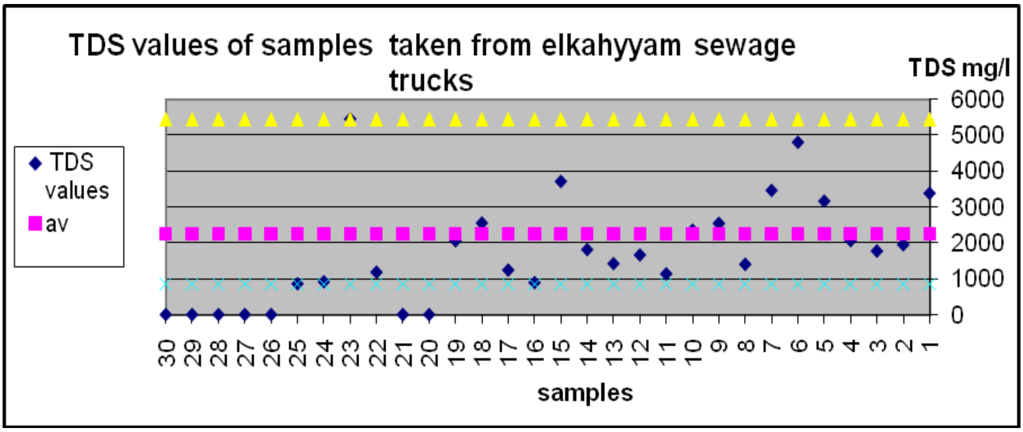

Fig No (5)

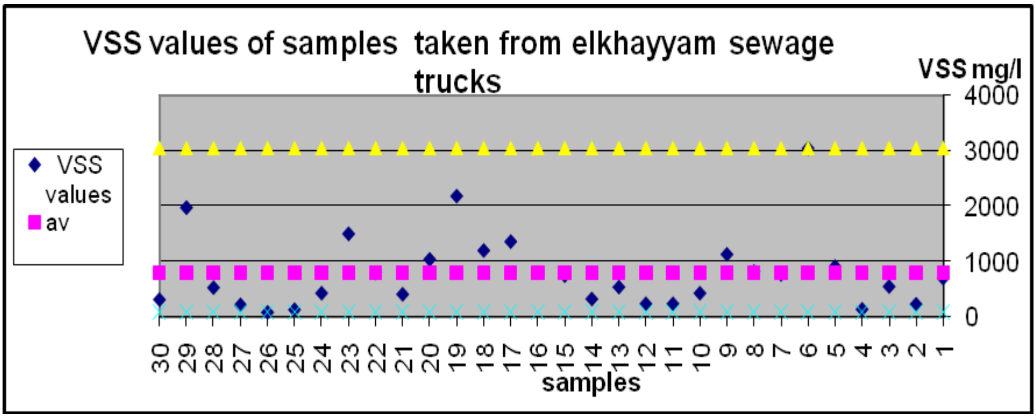

Fig No (6)

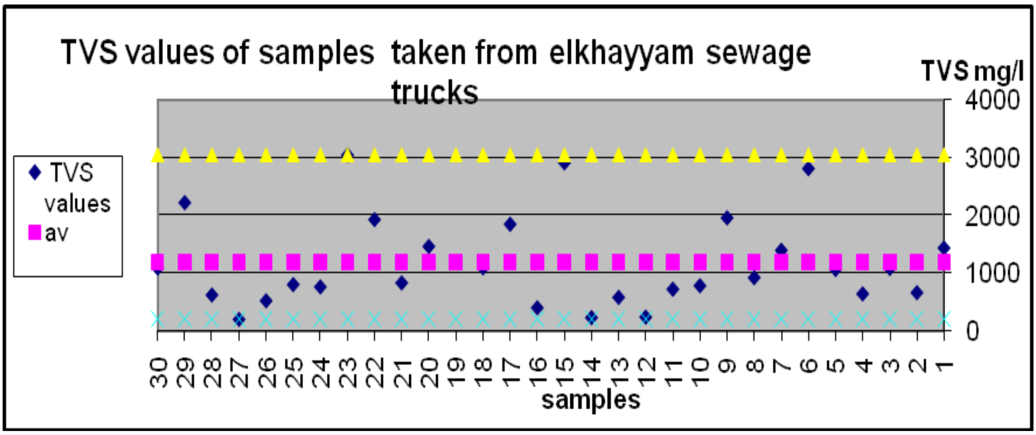

Fig No (7)

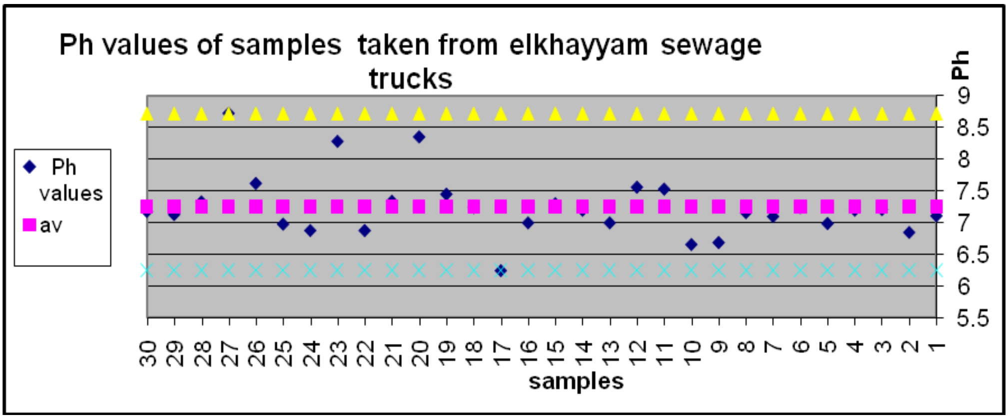

Fig No (8)

ANALYSIS

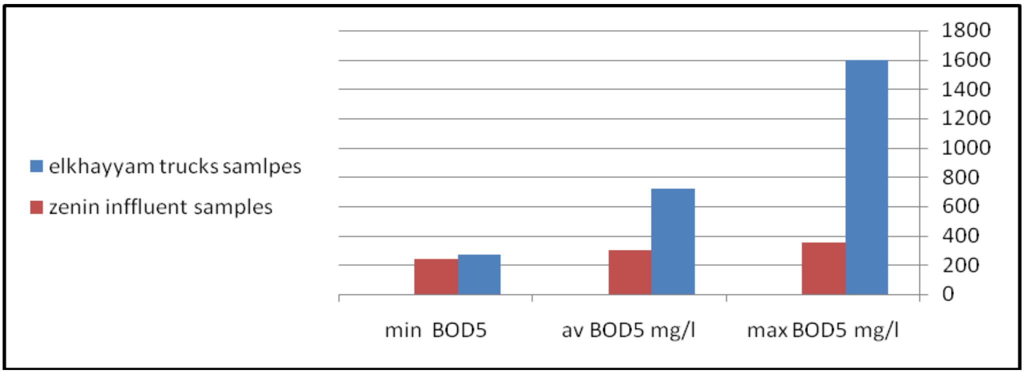

Fig No (9) (BOD5) Comparison between analysis of samples taken from sewage trucks of birak el khayyam & zenin influent.

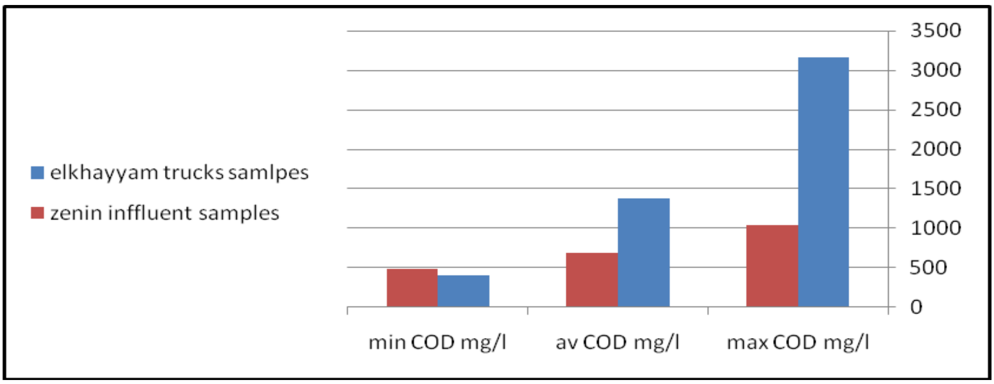

Fig No (10) (COD) Comparison between analysis of samples taken from sewage trucks of birak el khayyam & zenin influent.

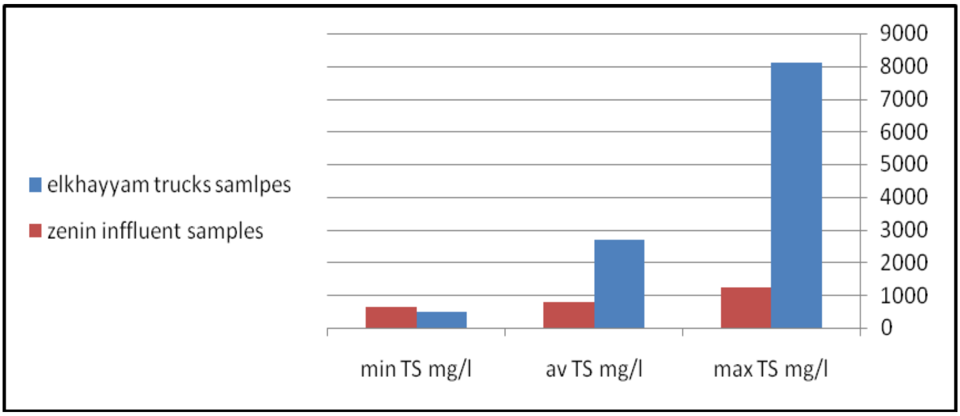

Fig No (11) (TS) Comparison between analysis of samples taken from sewage trucks of birak el khayyam & zenin influent.

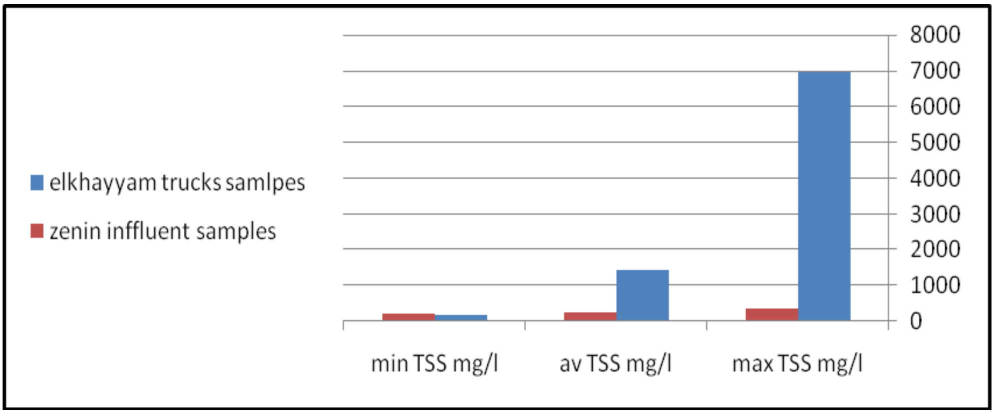

Fig No (12) (TSS) Comparison between analysis of samples taken from sewage trucks of birak el khayyam & zenin influent

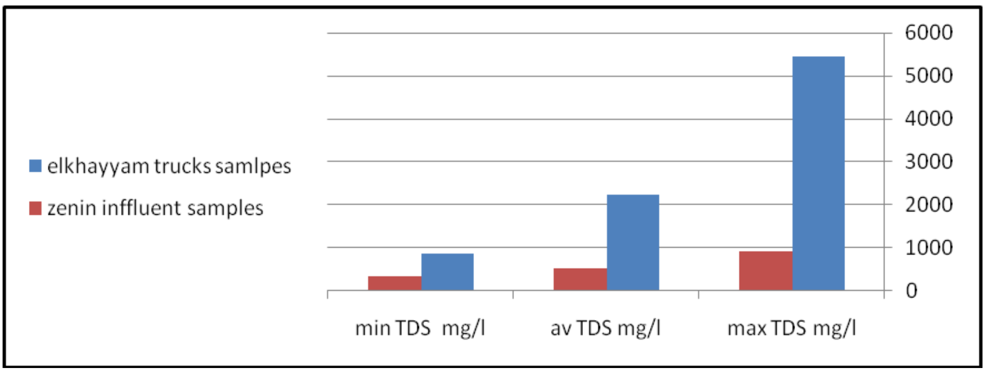

Fig No (13) (TDS) Comparison between analysis of samples taken from sewage trucks of birak el khayyam & zenin influent.

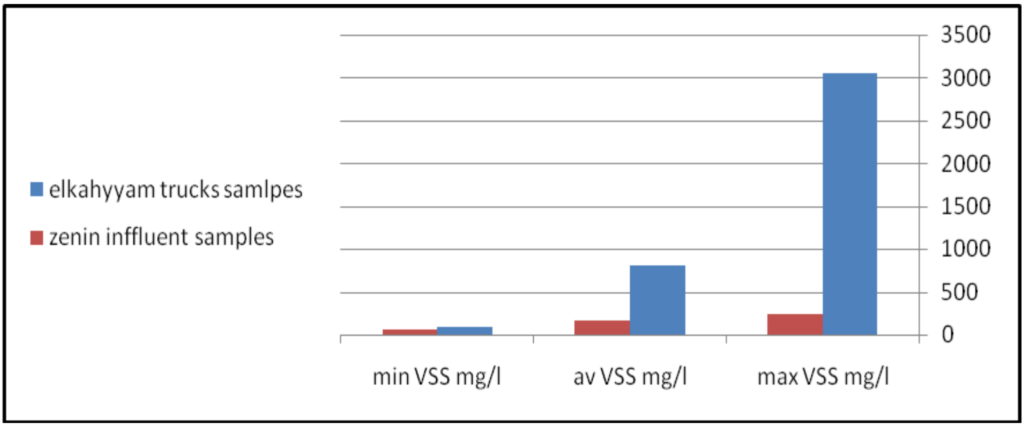

Fig No (14) (VSS) Comparison between analysis of samples taken from sewage trucks of birak el khayyam & zenin influent

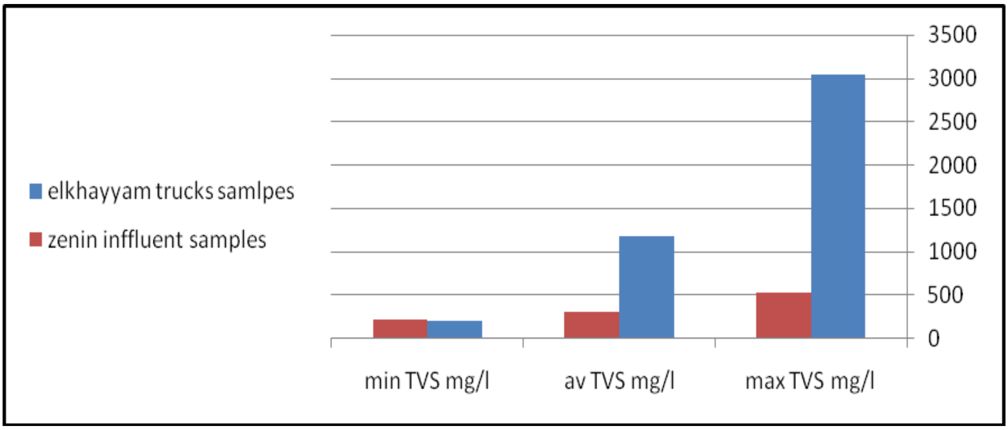

Fig No (15) (TVS) Comparison between analysis of samples taken from sewage trucks of birak el khayyam & zenin influent

As a result, the idea begins to consider the sewage system that consists of the following four elements:

First: collection works Second: pumping
Third: treatment Fourth: disposal

- Since the problem is primarily an economic one, so the consideration of an economic solution was necessary, and because the networks represent about 70% of the costs of the treatment system, the thinking to utilize the Japanese experience and Saudi experience applied in the Egyptian countryside which is the non-use of networks (in the urgent stage) in the assembly and dependence on cars by the natives, the private sector, which is one of the indirect participation to retain the assembly system as it is.
- As for the second stage, due to the assembly by the car system and the private sector, there would be no need to the pumping system and the drainage lines.

- From the analysis of the result average (BOD5)for desludging truck is 718 mg/l against 300mg/l for influent Zenin WWTP, average (COD)1383mg/l against 684mg/l, average TDS is 2250mg/l against 521 mg/l, average of TSS is 1430 mg/l against 253 mg/l , average of TVS is 1188 mg/l against 317 mg/l, average of VSS is 802 mg/l against 169 mg/l .In addition, this would also necessitate consideration of a system to deal with high organic loads and would lead us to the anaerobic system since its efficiency in dealing with high organic loads is much better than the low load.
- The removal of the treated water, there are agricultural drains that can release the water after treatment in such drains.
- From here the idea of the theory comes to reach an economic solution that saves the environment and improves the living condition of the citizens and therefore take the berak el khayyam village as a case study.

6. PROPOSED SYSTEM

- As for the collection system, the current situation will be retained (non-pipe system).Therefore, the costs of whole network establishment (collection works+pumpsworks) will be saved it represented 70% of total traditional works.
- Indirect public participation will be achieved through the participation of the natives due to desludging works, (average of 4.5 c per person/ month).
- The individual's water consumption is 100 liter/day and it is supposed that the average daily waste water/capita is 80liter, since the average individual's share of domestic sewage is 80% from water consumption.
- The system will save 55 million eg.p estimated cost for construction collection and pumping works for sewage system for the village proposed from N.O.P.W.A.S.D.
- Through the establishment of a treatment plant close to the drains out of the urban cordon approved by the ministry of housing represented in the general urban planning organization. The pollution cycle will be cut and the WWTP will be kept at a distance that range between 0.5-1 km out of the urban cordon of the village.
- An anaerobic treatment system (USAB/ USBR) proposed, butfrom the previous experiences of this system proved that its efficiency range between 60-80% so it was necessary to follow an aerobic system like the Sponch system or (trickling filter) and works without any mechanical energy and position energy.
- In a later stage, the system can be supplied with some lines that drain in the main collector, so the system would become from non-pipe to the traditional system after providing the required funds to generalize the first and second stages to all villages.

6.1 Advantages of the Proposed System.

- Matches the environmental conditions because it is developed from the current situation.
- Flexible and accepts development as being an urgent solution that can enter within the integrated traditional system in the future.
- Economic, the supply of the regression networks will reduce the costs by 70-80%,

So the service will be generalized to a larger sector at the same estimated costs of a convention system.

- Quick to maintain the environment from pollution, especially the water streams.
- Enhancing the indirect public participation through the participation of natives in the drainage costs
- Encouraging the private sector by conducting the drainage works by trucks and legalizing the situation.
- Reducing the water consumption because it was proved that the presence of networks will increase it.
- Minimizing the funds required for the water and drainage sector as a result of reducing the water consumption as well as domestic sewage discharge.
- Minimizing and violation of the agrarian lands.
- To find a compromise between upgrading and retention of the current situation.
- Removing the concept of the citizens that the government will supply them with utilities (traditional sewage system) through the political pressure at the times of elections.

7. CONCLUSION & RECOMMENDATION

7.1 Conclusion

Therefore, it is necessary to find a quick solution where such dimensions are all considered in the form of an urgent plant taking into account the utilization of international and national experiences and tailoring this with the Egyptian conditions and potentials to derive a system that matches Egyptian standared.

Taking Into Consideration Golden Advice Stated That:

Above all, these experiences show that there is no silver bullet there is not one single technology with the potential to solve all problems in every context. Sanitation solutions must be locally relevant and acceptable to those who will use and maintain all elements of a sanitation system - from toilet, to removal and transportation, to treatment and to use of products as potential agricultural inputs.

The idea of flexible solution (semi non-pipe system) was reached. In this system, the anaerobic treatment system USAB/USBR to be followed by aerobic system is suggested. The plant receives from trucks the desludging of the trenches as a first stage, and then in the second stage a main collector line is established, then in the third stage, a secondary collector line connected to the main line is established to receive the drainage from the houses.

So that the system established is equal to 20-30% of the costs of the convention system because of saving the cost of collection and pumping works .it will be by trucks (indirect public participation).

7-2 Recommendations

It is recommended to use semi non-pipe system in slums and rural areas, which haven't desert boarders; we will save 70-80% of the cost of any traditional system.

Not to implement the networks would encourage the public participation by the natives indirectly through the drainage of trenches on their own expense.

As result of high organic loads (averageBOD5 700 mg/l), so it is recommended to use anaerobic treatment system (UASB/USBR) followed by aerobic treatment system down flow hanging sponge reactor (DHS) or any cheap aerated system.

The land is allocated to the plant and the land area required for aerobic treatment is made to be implemented later on after the finishing of the anaerobic plant. It is recommended to establish equalizing storage, to guarantee the continuous stability of the hydraulic load, since the system efficiency in continuous drainage is much better than the intermittent drainage (the working hours8-16 a day). As well as reduces the fluctuation of the organic load by mixing the sewage.

Conducting preliminary study to identify the characteristic of flow resulting from mixing in equalizing storage.

The WWTP will establish next to the drains in east south of the village until the result of the drainage is removed after the treatment.

The system shall be dealt with exceptionally through the laws and regulations to meet the standard specifications for the drainage of the treated water on the water drains until completing the plan for implementing the projects, then resuming the application of the specifications again after the implementation of the aerobic stage, this is much better than not solving the problem and retaining the status quo

Paper introduce fourth physical planning solution for slums (previous solution are: remove- develop and retention the current situation) by Freezing the situation and establishing the treatment plant without networks.

LIST OF ABBREVIATION

T	Temperature
Ph	Power of hydrogen
BOD5	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TS	Total Solids
TSS	Total Suspended Solids
VSS	Volatile Suspended Solids
TDS	Total Dissolved Solids
UASB	Up flow Anaerobic Sludge Blanket
USBR	Up flow Septic tank/anaerobic Baffled Reactor
RBC	Rotating Biological Contractor
HRT	Hydraulic Retention Time
DHS	Down flow Hanging Sponge
C.A.P.M.A.S	Central Agency for Public Mobilization and Statistic
E.W.P	Egyptian Water Partnership
N.O.P.W.A.S.D	National Organization for Potable Water And Sanitary Drainage.

REFERENCES

1. قضية العشوائيات – ودور الوزارة فى معالجتها "الهيئة العامة للتخطيط العمرانى" ورقة عمل مقدمة من ا.د.م وزير الاسكان والمرافق والمجتمعات العمرانية.
2. الاطار العام للسياسات القومية المتعلقة بقطاع الصرف الصحى بمصر.تقرير اللجنة المشكله بقرار السيد وزير التعمير والمجتمعات الجديدة والاسكان والمرافق رقم 158 لسنة 1990 م.
3. الخطة الخمسية للدولة 20012/2007 .
4. تآكل الأراضى الزراعية من منظور التخطيط العمرانى فى مصر" التقرير النهائى" يناير 2007 .
5. المخطط الاستراتيجى العام لقرية برك الخيام (الهيئة العامة للتخطيط العمرانى ,وزارة الاسكان والمرافق والتنمية العمرانية)
6. (الجهاز التنفيذى لمشروعات المياه والصرف الصحى للقاهرة الكبرى والاسكندرية- المشروع المقترح للصرف الصحي للقرية)
7. Housing and sustainable development in countries sheltering the urban poor in Egypt, ahmed m.soliman
8. Egypt census prepared by the "central agency for public mobilization and statistics" (CAPMAS) published every with the latest is the 1996.
9. The national and some governorates "human development report" prepared and published annually by the "institute of national planning (INP) and the United Nations development program (UNDP) ".
10. The data available through the different survey conducted by the" Ministry of local development "(MOLD) through "organization for reconstruction and development of Egypt villages"(ORDEV).
11. The "master plan for water and wastewater in Egypt governorates" (MHUNC)through the "national organization for potable water and sanitary drainage"(NOPWASD)
12. Jica Training Course on " Water Resources and Environmental Management in Arid Region" in Japan 2005
13. Koster and lettinga: UASB process.
14. Anaerobic treatment of wastewater by Tarek Ismail M.Sabry.
15. Ehab ruzzik Ph.D 2004
16. De Man, A.W.A. (1990) Anaerobic purification of raw sewage with the aid of granular sludge in UASB reactors. Report Agricultural University of Wageningen, Department of Water Pollution Control.
17. Fergala, M.A.A. (1995) The Anaerobic Treatment of Complex Wastewater. PhD Thesis, Van Hall Institute, Groningen, Netherlands.
18. . Water Science and technology. 15. 1.
19. Jeris, J.S. (1982) industrial wastewater treatment using anaerobic fluidized bed reactors. Presented at IAWPRC Seminar on Anaerobic Treatment? Copenhagen, Denmark.
20. Lettinga, G. Pette, K.C.H., Vletter, R. and Wind, E. (1977) Anaerobic purification of beet sugar wastewater at semi technical scale.
21. Lettinga, G. et al. (1984) high rate anaerobic wastewater treatment using the UASB reactor under a wide range of temperature conditions.
22. Mara, D.D. (1976) Sewage Treatment in Hot Climates, Wiley, Chichester.
23. McCarty, P.L. (1981) One hundred years of anaerobic treatment. Presented at the second international Conference on Anaerobic digestion. Travemunde, Germany.

24. McCarty, P.L. (1990) Modelling of anaerobic processes. Presented at IAWPRC Seminar on Anaerobic Treatment, Valladolid, Spain.
25. Metcalf and Eddy inc. (1979) Wastewater Engineering: Treatment, Disposal, Reuse, McGraw-Hill, New York.
26. Sabry, T.I. (1999) The Upflow Anaerobic sludge blanket reactor.

منهاجية تخطيط نظم الصرف الصحي المنزلي في المناطق العشوائية والريفية بطريقة اقتصادية

أصبحت قضية المناطق العشوائية من أخطر المشاكل التي تواجه المجتمع المصري حيث أن 57% من سكان مصر يعيشون في الريف المصري &20% في العشوائيات في حين تم تغطية أقل من 5% فقط من الريف بخدمة الصرف الصحي وللمشكلة أبعاد اقتصادية وعمرانية وإستراتيجية واجتماعية وبيئية والتشريعات .وتناول البحث التجارب الدولية والمحلية الناجحة المتعلقة بهذه ألمشكله وتم أخذ قرية كنموذج وأخذ عينات من ناتج كسح الترنشات الموجودة بالقرية وتحليل تلك النتائج ومقارنتها بنتائج تحليل العينات عند مدخل محطة زنين (كمحطة تقليدية).وتم اقتراح نظام (Simi non-pipe system) كحل عاجل وهو عبارة عن إنشاء خط مجمع رئيسي وذلك لاستقبال التصرفات الناتجة من كسح الترنشات كمرحلة عاجلة ثم محطة معالجة تعمل بالنظام اللاهوائى UASB/USBR (كنظام مناسب لطبيعة وخواص ناتج كسح السيارات) وتتبع بنظام هوائي لاحقا ويتم التخلص من السيب النهائي بالمصرف الزراعي الموجود بالقرية.