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A Study of the Evaluation of Community Participation in Egyptian Rural Sanitation- Case Study

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Abstract

Egypt is facing different challenges nowadays, due to unsafe disposal of wastewater. Billions of people worldwide do not have adequate domestic wastewater treatment, which leads to the spread of infectious diseases and estimated deaths around 2.1 million every year. In recent decades, both developing and developed countries have made significant efforts to improve sanitation and wastewater treatment technologies. The disposal of untreated wastewater is considered a critical problem for health and environmental issues. It causes contamination of rivers, groundwater and wide spread of viruses and diseases. Depending on centralized treatment of wastewater, which is considered an ineffective solution. Due to excessive cost of established, operation and maintenance, however many countries went to the development of the sewage system through decentralized and community participation. The objective of the current research is to assess different case studies of community participation and its impact on different plants efficiency in Egypt. Ezbet Al-Sheikh Yacoub, Beni Suef that applied wetland and Abd ELkareem Eissa, EL-Fayoum that applied up flow septic tank an aerobic baffled reactor were selected. Analysis to the influent and effluent samples were conducted and different parameters were measured to evaluate the efficiency of wastewater treatment plants. A sample of sludge was examined from Ezbet Al-Sheikh Yacoub plant and was exposed to type of earthworms called Eisenia fetida not only for the purpose of safe disposal, but also to turn them into safe product that can be sold.
Finally, we concluded that the treatment plant of Ezbet Al-Sheikh Yacoub is inefficient to comply with Law 48 of 1982 due to wrong operation and defects in implementation of the station, but the treatment plant of Abd EL- kareem Eissa is efficient and complies with Law 48 of 1982.

Keywords
Community participation, decentralized wastewater treatment, rural sanitation, wetland, vermicomposting.

1. Introduction

Safe and appropriate disposal of wastewater is a basic requirement for sanitation and public health protection. However, the disposal of sewage is the obvious obstacle facing the Egyptian community in rural areas and villages. This is due to the lack of sewerage systems around these areas. The one method used in disposing wastewater is through constructed septic tank and wastewater is transport to the nearest waterway through cars scavenging without any treatment. When water contaminated with sewage reaches the canals used in agriculture. It may cause many diseases as (acute respiratory infections, diarrhea, hepatitis and malaria) (Abdel-Razek, 2016). The transport of wastewater by car scavenging is considered an economic burden on the citizens, where they are transferred more than once a month, some people's living conditions do not allow hiring scavenging cars, in result they get rid of wastewater directly on the streets, causing the spread of diseases in addition to the bad odor, other villages use bottomless trenches for the disposal of sewage, this causes health risks and contaminated ground water, especially if the ground water with a high level as in the villages of the Delta (Azeem, 2014).

Egypt suffers from low coverage of appropriate sanitation system in rural areas. (Sabry, 2010) reported that the use of different conventional systems are extremely high, this high cost of construction, installation, operation and maintenance. It is above the budget of the government (El-Gendy, et al, 2012). One of the best solutions to get out of the sanitation crisis is restoring wastewater treatment plant of low-cost of

cooperation with the household. According to the above-mentioned reasons, Egypt growing wastewater policy of rural sanitation is going towards relying on decentralized systems and community participation rather than centralized. There are many national and international countries went to development their sewage system through decentralized wastewater treatment and community participation. The village Kom EL Dabaa that located in the Naqada markaz, governorate of Qena is local experiences in Egypt depending on community participation in decentralized wastewater treatment. (Azeem, 2014) illustrated the reason that made the villager of Kom EL Dabaa preferred community participation and decentralization, this is due to the lack of appropriate sewerage system the household used bottomless trenches, this leads to the presence of bogs, which cause the spreading of diseases, Community participation has an effective role to complete the sanitation process in all its stages as follow: -

1. The villagers funded the field tests, project design and cost of construction of the pump station and the site fence

1. The households pay for connection to the interceptor, monthly fee for operation, maintenance and for planting the wooden forest.

2. Qena governorate contribute the desert of WWTP and wooden forest, they also lighting and pavement of the road to the treatment plant

Vermont State that located in the Novel England region of the northeastern USA (Map of World, 2017)**,** is international experiences depending on community participation in decentralized wastewater treatment. (Vermont Department of Housing and Community Affairs, 2008) discussed the reasons that made the Vermont preferred community participation and decentralization than centralization in the sanitation as follow: -

1. In the period of 1970 -1980 centralized wastewater treatment infrastructure was funded by federal grant, but in the late of 1980 federal grant transformed from grant to loans

Community participation has an effective role to complete the projects of decentralized wastewater treatment as follow: -

2. Maintaining a documented notebook by the society at the general library or town office or posting information on a municipal website are methods to preserve people update
3. Working with Selected board or other chosen official's committees help to overcome the obstructions and ease a lot of procedures
4. Writing essays for national newspapers are good methods to preserve people knowledgeable about wastewater planning.
5. Th Wastewater advisory committee obtain the funding for the planning and construction phase but as for the phase of operation and maintenance (O&M), the town has rented a service provider, the cost of O&M is paid by the residents (Clark, 2005).

2. Technical Part

1. Vermicomposting by Eisenia fetida

(Aira *et al.*, 2011) reported that the increasing rate of organic residues produced had become difficult in handling and dealing because it needs method for disposal or management. Human produce more than 38 billion m^3 of organic waste annually (Nguyễn, 2012)**.** According to (Londhe and Bhosale, 2015) they suggested one solution to the problem is vermicomposting. It is produced from bio-fertilizer by the bioconversion of organic waste, because of earthworm's activity which the gut of the earthworms works as a bioreactor. (Karimi *et al.*, 2017) shows reduction in number of Fecal coliform in the raw sample of cow manure–sewage sludge from 6,500,000 to 2400 MPN/g, also Fecal coliform decrease in the raw sample of cow manure–organic waste from 350000 to 800 MPN/g within 8-week periods, the parasite eggs were totally eliminated in two composting cases in the second week by using Eisenia fetida.

3. Materials and Methods

The study covers the analysis of Ezbet Al-Sheikh Yacoub and Abd EL- Kareem Essa to measure the efficiency of wastewater treatment plant. We also will take a sample of the sludge coming out of Ezbet Al-Sheikh Yacoub plant and exposed to the Eisenia fetida. Ezbet Al-Sheikh Yacoub is located in EL Fashn District, Beni Suef governorate. The plant serves three districts, Ezbet Sheikh Yacoub, Ezbet Zaki Wehbe and Ezbet Jafar with two pump stations one in Ezbet Al-Sheikh Yacoub and the other is in Ezbet Jafar. The designed average flow is 617m^3 per day while, the actual average flow is about 357 m3 per day, the designer is Eng / Anwar Manaf. The construction cost of sewer system, force line and pump station are about 711500 Egyptian pounds, in addition to the cost of WWTP, which approximately values 306000 Egyptian pounds. The construction cost is financed by EFG Hermes Foundation under the name of "Ro'ya Project ("FEG HERMES Foundation," 2008). In addition to CDA (community Development Association) of Ezbet Jafar which contributed with 100,000 EGP to connect them to the public WWTP. However, the land pump station was donated by villagers. The Ministry of water resources and irrigation have donated the land of WWTP

Abd ELkareem Eissa village is located in Manshiat Bany Etman – Sonoras district, EL-Fayoum Governorate, The designed average flow is about 200 m3 per day(Reymond, 2013). The actual average flow is about 128 m3 per day, Dr Tarek Sabry is the designer. The total cost of the project is 940000 EGP, the construction cost of WWTP is 300000 EGP and is financed by Ministry of irrigation and water resources through the funding program of Netherlands, the land of WWTP was donated by villagers, the cost of sewer

system is about 630000EGP and financed by local unite of Sonoras (Reymond, 2013).

3.1 Community participation

Figure (1) and (2) illustrates the community participation in Ezbet Al-Sheikh Yacoub and Abd ELkareem Eissa sewage system respectively

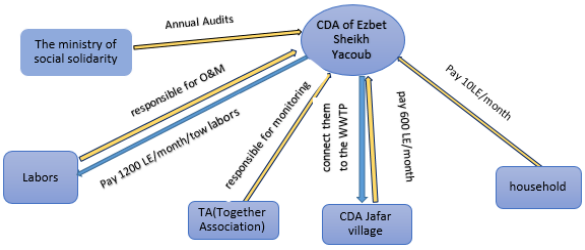

Figure (1) Community participation in Ezbet Sheikh Yacoub sewage system

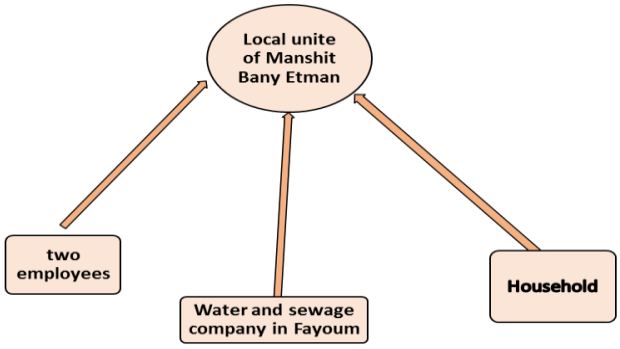

Figure (2) Community participation in Abd EL-kareem Eissa sewage system

3.2 System components

The components of the plants of Ezbet Al-Sheikh Yacoub and Abd ELkareem Eissa are presented in table (1) and (2) respectively but the layout of the plants of two villages are shown in figure (3) & (4).

Table (1): shows the component of Ezbet Al-Sheikh Yacoub WWTP.

	Units	No of units	Dimensions (length×width)
1	Sedimentation tank	3	5×2
2	Sludge drying beds	3	4×3
3	Air injection	4	2.3×2
4	Gravel Bed Hydroponic	4	87.7×2
5	Maturation Ponds	1	30×8.75

Table (2): shows the component of Abd Elkareem Eissa WWTP.

	Units	No of units	Dim (L*W*D) m
1	Up flow septic tank	2	6×3×3
2	Anaerobic baffled reactor	2	9× 3×1.4
3	Basin chlorine mixing	1	Diameter1×1

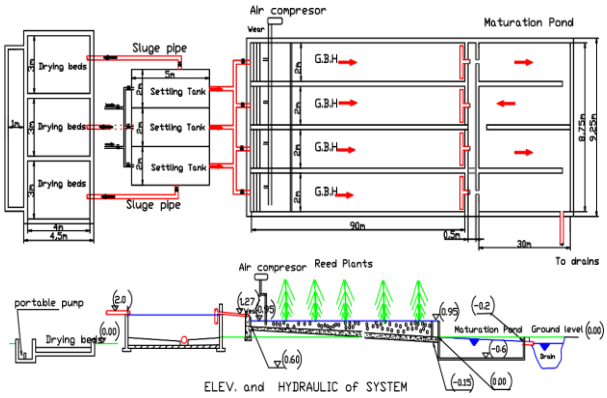

Figure (3): layout and vertical section of wastewater treatment plant.

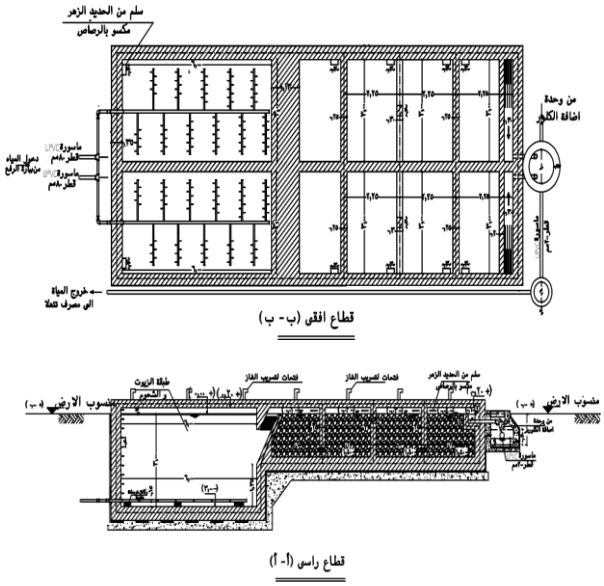

Figure (4): Vertical and horizontal section of WWTP in Abd EL-kareem Eissa

3.3 Vermicomposting

The sludge was brought from Ezbat Al-Sheikh Yacoub plant, it was presented in drying bed for five days. It was placed in a plastic container of dimensions (90 x 40×30) cm in a farm. A sample of the sludge was taken for analysis.

The sludge was left in the plastic container for seven days as a preliminary treatment. Then the cardboard sheets were placed with some grams of crushed egg shells. Moreover, 450 worms of red wiggler of different sizes were introduced to the sludge. The red wiggler was borrowed from Dr. Hisham Hajjaj's farm with no cost, the sludge was sprinkled with water to maintain moisture. Media was added in another side of the plastic container. The media was made of cardboard and dry leaves, then it was sprinkled with water. The media was put in an order to allow the red wiggler to go in it, in case that the sludge isn't appropriate. The sludge and the media were covered with moist gunny bag.

4. Results and Discussions

The samples from Ezbet Al-Sheikh Yacoub and Abdel Kareem Essa were collected from the influent and effluent of the wastewater treatment plant. Table (3) & (4) shows the COD Characteristics of the influent, effluent and the removal efficiency of Ezbet Al-Sheikh Yacoub and Abdel Kareem Essa WWTP while table (5) & (6) shows the TSS Characteristics of the influent, effluent and the removal efficiency of two villages. The results discussed will include sludge that coming out of the Ezbet Al-Sheikh Yacoub plant and after digesting sludge by exposing it to kind of earthworms called Eisenia fetida.

Table (3): shows COD influent and effluent samples Characterization and the removal efficiency of Ezbet Al-Sheikh Yacoub WWTP.

Parameter	COD		
	Inf	Eff	removal efficiency
S1 during April	451	432.5	4%
S2 during May	775	257.5	67%
S3 during July	457.5	127.5	72%
S4 during September	1308	730	44%
S5 during November	1163.5	492	58%

Table (4): shows COD influent and effluent samples Characterization and the removal efficiency of Abdel Kareem Essa WWTP.

Parameter	COD		
	Inf	Eff	removal efficiency
S1 during April	601	56.5	91%
S2 during May	515	75	85%
S3 during July	647	93.5	86%
S4 during September	665	140.5	79%
S5 during November	1590.5	41.5	97%

Table (5): shows TSS influent and effluent samples Characterization and the removal efficiency of Ezbet Al-Sheikh Yacoub WWTP

Parameter	TSS		
	Inf	Eff	removal efficiency
S1 during April	178	157.5	12%
S2 during May	163	109.5	33%
S3 during July	128	21	84%
S4 during September	776	365	53%
S5 during November	489	159.5	44%

Table (6): shows TSS influent and effluent samples Characterization and the removal efficiency of Abdel Kareem Essa WWTP

Parameter	TSS		
	Inf	Eff	removal efficiency
S1 during April	123.5	19.5	84%
S2 during May	149	23.5	84%
S3 during July	512.5	26.5	95%
S4 during September	382.5	42.5	89%
S5 during November	1117	25.5	98%

From the previous tables, relations were derived to show the effluent of each parameter that was compared with law 48 /1982 in Ezbet Al-Sheikh Yacoub and Abdel Kareem Essa respectively in the following curves as shown in figure (5) & (6) & (7) & (8) & (9) & (10).

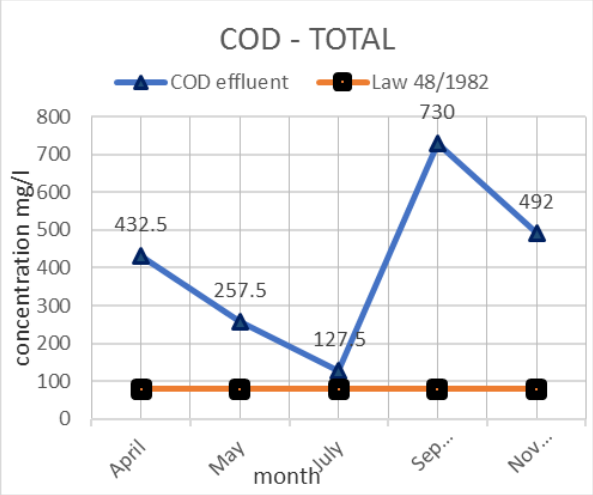

Figure (5) shows comparison COD of the effluent by Law 48 /1982 of Ezbet Al-Sheikh Yacoub WWTP

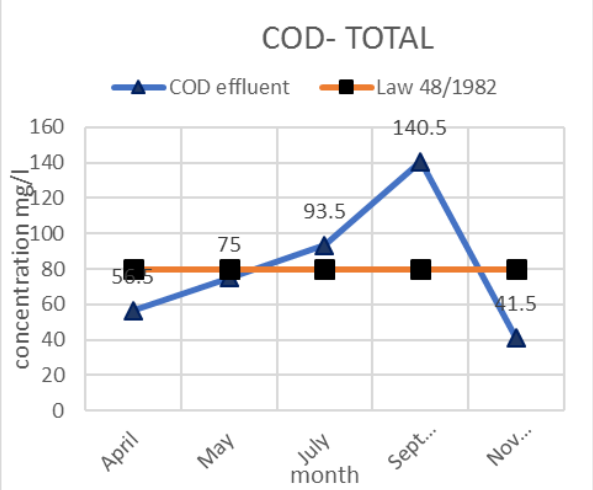

Figure (6) shows comparison COD of the effluent by Law 48 /1982 of Abdel Kareem Essa WWTP

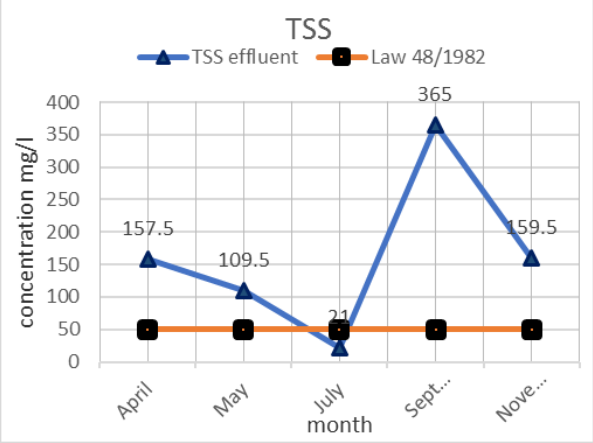

Figure (7) shows comparison TSS of the effluent by Law 48 /1982 of Ezbet Al-Sheikh Yacoub WWTP

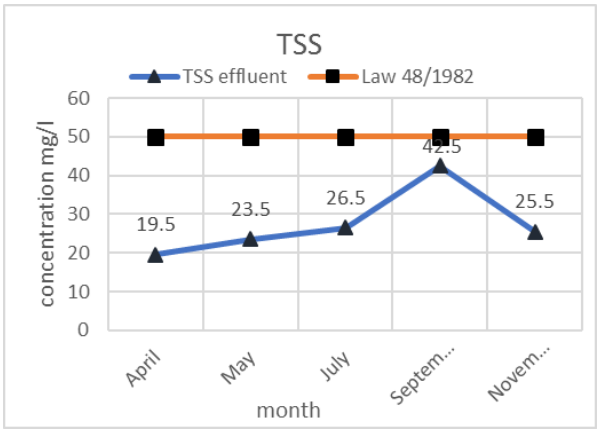

Figure (8) shows comparison TSS of the effluent by Law 48 /1982 of Abdel Kareem Essa WWTP

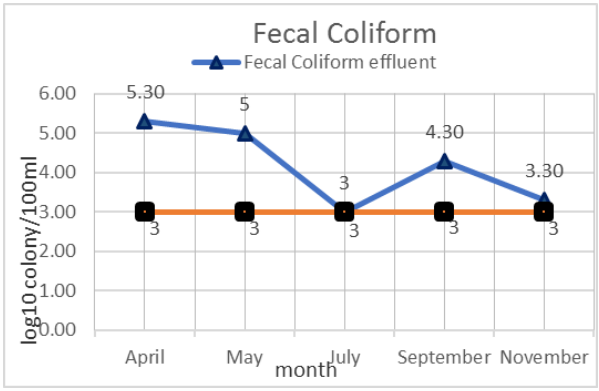

Figure (9) shows comparison Fecal Coliform of the effluent by Law 48 /1982 of Ezbet Al-Sheikh Yacoub WWTP

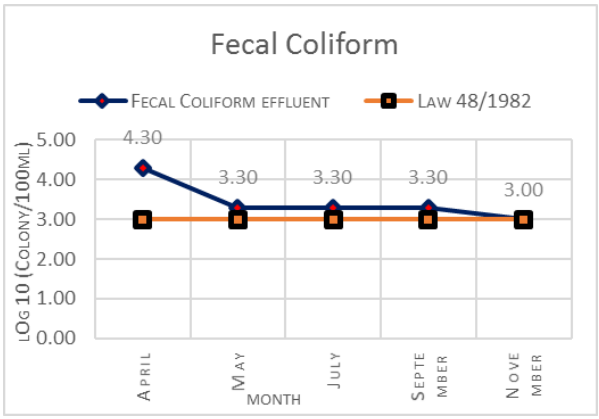

Figure (10) shows comparison Fecal Coliform of the effluent by Law 48 /1982 of Abdel Kareem Essa WWTP

In April, the removal efficiency of COD and TSS of Ezbet Al-Sheikh Yacoub was respectively 4%&12 % as shown in table (3) & (5) and the effluent of COD, TSS and Fecal Coliform was 432.5 mg/l, 157.5 mg/l and $2*10^5$ colony/100 ml respectively as shown in figure (5) & (7) & (9) which didn't comply with law 48 /1982, During this time the pump station of Ezbet Sheikh Yacoub was pumping the wastewater to the plant. The pumping station of Ezbet Al-Sheikh Yacoub, and Jafar are operated manually once every 12

hours and all the quantity of wastewater is pumped at once, these lead to the death of some microorganisms, which resulted in the low removal efficiency.

There are four gravel bed hydroponic channels, one is stand by, the other is out of service because the wall of it seeps the water so that only two channels work. However, the removal efficiency of COD and TSS of Abdel Kareem Essa was respectively 91%&84% as shown in table (4) & (6).

The effluent of COD, TSS and Fecal coliform was 56.5mg/l, 19.5 mg/l and $2*10^4$ colony/100 ml respectively as shown in figures (6) & (8) & (10), the effluent of COD, TSS comply with law 48/1982 but fecal coliform didn't whereas the chlorine unit was out of order because electricity was cut off.

In May, the removal efficiency of COD and TSS of Ezbet Al-Sheikh Yacoub was 67% &33% respectively as shown in table (3) & (5), the effluent of COD, TSS and Fecal Coliform was found to be 257.5 mg/l, 109.5 mg/l and $1*10^5$ colony/100 ml respectively as shown in figure (5) & (7) & (9) which also didn't comply with law 48 /1982. But efficiency removal of COD and TSS of Abdel Kareem Essa was respectively 85%&84% as shown in table (4) & (6).

The effluent of COD, TSS and Fecal coliform was 75mg/l, 23.5 mg/l and $2*10^3$ colony/100 ml respectively as shown in figure (6) & (8) & (10), the effluent of COD, TSS comply with law 48/1982 but fecal coliform didn't.

In July, the removal efficiency of COD and TSS of Ezbet Al-Sheikh Yacoub was 72%&84% respectively as shown in table (3) & (5). The effluent of COD, TSS and Fecal Coliform was 127.5 mg/l, 21 mg/l and $1*10^3$colony/100 ml respectively as shown in figure (5) & (7) & (9). TSS and Fecal Coliform complied with law 48 /1982 but COD didn't. The effluent of COD, TSS and Fecal coliform were the best during July, the result enhanced due to the high temperature however efficiency removal of COD and TSS of Abdel Kareem Essa was respectively 86%&95% as shown in table (4) & (6).

The effluent of COD, TSS and Fecal coliform was 93.5mg/l, 26.5 mg/l and $2*10^3$ colony/100 ml respectively as shown in figures (6) & (8) & (10), the effluent of TSS comply with law 48/1982 but COD and fecal coliform didn't.

It was noticed that the removal efficiency decreased in May and July than April, because the sludge had to be removed from the up flow septic tank every six months but it completed eleven months until July without removal, the sludge of the up flow septic tank has been lifted and the plastic and gravel filters of anaerobic baffled reactor were washed at the end of July.

In September, we agreed with the members of Ezbet Al-Sheikh Yacoub and Ezbet Jafar associations to operate the two pump Stations together and observe the effect of water pumping once on the efficiency of the plant. We noticed Water moves from the top of one channel of gravel bed hydroponic, not through it and there were sediments floating in the sedimentation tank because the sludge is removed once a week instead of three times a day, it result in clogging of gravel bed hydroponic when the floating sludge is discharged to it.The sludge don't pull three times a day from sedimentation tank, because pulling them require operation the pump to raise the water leaking from the sludge in drying bed and the pump burned several times and cost of buying it is high, due to the lack of financial, they had to remove the sludge once a week.

The removal efficiency of COD and TSS was 44%&53% respectively as shown in table (3) & (5). The effluent of COD, TSS and Fecal Coliform were 730 mg/l, 365 mg/l and $2*10^4$ colony/100 ml respectively as shown in figure (5) & (7) & (9), which didn't comply with law 48 /1982 on the other hand efficiency removal of COD and TSS of Abdel Kareem Essa were respectively 79%&89% as shown in table (4) & (6).

The effluent of COD, TSS and Fecal coliform was 140.5mg/l, 42.5 mg/l and $2*10^3$ colony/100 ml respectively as shown in figures (6) & (8) & (10), the effluent of TSS comply with law 48/1982 but COD and fecal coliform didn't. The bad result of the COD may be due to all quantity of the sludge may have raising during maintenance.

In November, the removal efficiency of COD and TSS of Ezbet Al-Sheikh Yacoub was respectively 58%& 44% as shown in table (3) & (5). the effluent of COD, TSS and Fecal coliform respectively was 492 mg/l, 159.5 mg/l and $2*10^3$ colony/100 ml as shown in figure (5) & (7) & (9). They didn't acceptable according to the law of 48 in the year 1982 but efficiency removal of COD and TSS of Abdel Kareem Essa was respectively 97%&98% as shown in table (4) & (6).The effluent of COD, TSS and Fecal coliform was 41.5mg/l, 25.5 mg/l and $1*10^3$ colony/100 ml respectively as shown in figures (6) & (8) & (10), the effluent of COD, TSS and Fecal coliform comply with law 48/1982, From the above mention it is clear that Fecal coliform didn't comply with Law 48/1982 in all the results except November. Chlorine concentration was measured by chlorine concentration device at the tank and was found to be less than 0.2 mg / l

Chlorine concentration was measured at sodium hypochlorite and found to be 0.4 mg /l. The chlorine concentration at sodium hypochlorite solution is range 14 mg / l.

It means sodium hypochlorite solution adulterate and don't suitable for use.

4.1 Vermicasts

The sample of the sludge coming out of the Ezbet Al-Sheikh Yacoub plant was taken and exposed it to kind of earthworms called Eisenia fetida.

A significant decrease in the number of total coliform from $15*10^5$ to $43*10^3$ Colony/g, fecal coliform from $71*10^4$ to $24*10^3$ Colony/g, Salmonella and Shigella bacteria from $8*10^3$ to 23 Colony/g within two months most heavy metal have reduced as follow:-

Iron from 2.3to 1.1%, zinc from 220.35 to 60.95 mg/kg, copper from 71.35 to 20.85 mg/kg, Manganese from 168.1 to 101.3 mg/kg, Cadmium from 1.3 to <.1 and lead from 7.4 to .05 mg/kg. A slight increase was

observed in Cobalt from <.2 to 3 mg/kg, however Nickel increase from 21.1 to 54 mg/kg, and it may be as a result of accumulation of heavy metals in dead worms

5. Conclusion

1. The previous results showed that the main reason of weak results of Ezbet Al-Sheikh Yacoub plant is the wrong operation of the plant, in which sludge is pulled once a week instead of three times a day. This causes the clogging the channel of the gravel bed hydroponics. Also operating the pump station every 12 hours may be result in death of some microorganisms. There are faults in the implementation of the system. The wall of one channel of gravel bed hydroponics beside the drain seep the water.

2. The previous results showed that, Eisenia fetida have the ability to breakdown the sludge, it has the ability to reduce the number of viruses present in the sludge as total coliform, fecal coliform and Salmonella and Shigella bacteria Moreover, it reduces the heavy metals present.

3. The previous results showed that, the system of Abdel Kareem Essa is efficient, the effluent of COD & TSS comply with Law 48 of 1982 except July and September, COD didn't, the reasons due to delayed maintenance in July whereas the sludge had to be removed from the up-flow septic tank every six months but it completed eleven months until July without removal. All quantity of the sludge drawn out during maintenance in the late of July and most probably it had bad effect on the result of COD in September. Fecal coliform a didn't comply with Law 48/1982 in all the results except November.

Chlorine concentration was measured at the tank and was found to be less than 0.2 mg / l. Chlorine concentration was measured at sodium hypochlorite and found to be 0.4 mg / l. It means sodium hypochlorite solution adulterate and isn't suitable for use.

6. Recommendations

1- There should be governmental committees responsible for follow-up such as the holding company and water and Sewerage Company.
2- The designer contract must state on following-up for at least ten years.
3- Annual training for the members of the association and the laborers of the stations must be performed.
4- The availability of a booklet manual for operation and maintenance with a cylinder with a simplified explanation of operation and maintenance.
5- One member of the Society of the Development Association should be a member of the People's or Shura Council or their representative.

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