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The sustainability of wastewater treatment efficiency and its estimated impact for onsite wastewater treatment plant systems in semi-urban areas: a Khan Yunis case study

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ABSTRACT

Public health could be harmed by the dumping of wastewater into the environment. Cesspit systems are the most common type of treatment used in homes in semi-urban areas of the Khan Yunis. The Gaza Strip's issues with sewage treatment have come under more and more scrutiny in recent years. By the end of 2014, only 74% of these areas had drainage and wastewater treatment systems. To build sewage treatment systems in rural regions that are dependable, it is vital to evaluate the technologies currently in use. By performing case studies on 24 facilities that had been in operation for at least a year, the sewage treatment technologies were assessed as currently being employed in semi-urban areas. The purpose of our study, which was conducted between 2012–2014, was to evaluate the situation at the time and identify any issues related to onsite wastewater treatment in semi-urban areas. In semi-urban regions, decentralized sewage treatment is the most popular wastewater treatment method. The results show that the technique is efficient at eliminating contaminants. The study underlines the necessity of establishing criteria for judging the effluent quality, considering several target contaminants. Findings also demonstrate that effluents can be recycled to satisfy various environmental standards.

Keywords: Onsite wastewater treatment; Biological oxygen demand; Chemical oxygen demand; Faecal coliform; Total suspended solids; Total dissolved solids

1. Introduction

The release of emerging pollutants and pathogens found in wastewater is a growing concern because it may have an impact on the environment and drinking water supplies. The status of growing pollutant and pathogen mitigation in the decentralized wastewater treatment processes has drawn greater attention in this decade as there have been an increasing number of small-scale decentralized wastewater systems installed internationally. In the past few years, issues with sewage treatment in semi-urban regions of the Gaza Strip have drawn more and more attention. However, the Gaza Strip's sewerage infrastructure is in disrepair, and it is believed that only roughly 74% of the population is connected to the sewerage network [1]. The alternative wastewater disposal method in semi-urban regions is the cesspit. Compared to other industries, agriculture uses the most water. Water reuse for irrigation of agricultural crops with treated wastewater is thus becoming more and more necessary.

Only a small part of larger urban centers to have centralized sewerage and wastewater treatment facilities, and in densely populated places, on-site sanitation is frequently inappropriate. It has been noted that the collection of wastewater and its treatment at a centralized treatment facility cannot be viewed as an economically viable and sustainable alternative because it depends on advanced treatment technology and highly qualified technical expertise for its operation and maintenance [2,3]. Since it involves treating and discharging or reusing wastewater close to its source of generation, the decentralized wastewater treatment system

(DEWATS) might be implemented as a helpful intermediate and complementary option, especially in developing countries, to address this problem [3]. While batch reactors like the sequencing batch reactor and filtration employing various membranes are established as standard treatment systems in rich countries, natural or sophisticated treatment methods like DEWATS are frequently employed in poor nations [4]. Before implementing a certain treatment technology, the site conditions need to be assessed to define the location-specific treatment system [5]. According to Battilani et al. [6], DEWATS technologies are piquing the interest of water stakeholders who are eager to adopt new single-family, onsite, and cluster technology, as well as advanced wastewater treatment to lower the cost of centralized wastewater treatment, which is governed by an expensive piping infrastructure. Very little study has been conducted in the decentralized wastewater industry to determine the long-term performance of onsite or cluster systems or the impact that different management strategies may have by performance.

Developing nations currently select the best development strategies, with the majority favoring sustainable development in terms of economy, technology, the environment, and society [7]. All forms of economic and domestic activity result in the production of wastewater, which has unique properties based on the technological production process (unitary or mixed operations and/or processes), collecting system, transport, and on-site treatment facilities, all of which call for smoothly functioning systems and/or highly effective integrated management systems. Around the world, the wastewater management system (WWMS) of urban areas connected to rural areas, or for industrial sites connected to agricultural areas in a specific geographical region, is undergoing major growth [8]. The management of all types wastewater generated by various productive activities (or not productive ones, like domestic wastewaters) becomes a local responsibility, a requirement of efficient, sustainable WWMS, and a local demand of modern society in terms of environmental protection, standard requirements for water quality, minimization of environmental impact due to produced wastes, pollution prevention and control, and especially of natural resources conservation in local communities. The three fundamental systemic components of all WWMSs are wastewater collection, wastewater treatment, and either disposal or reuse of treated wastewater [9]. In centralized systems, particularly in small communities with low population densities, associated with industrial platform sites being kept as minimal as possible in decentralized systems, the first component, wastewater collection, costs more than 60% of the total WWMS budget but is at least crucial for wastewater treatment and disposal. Due to high capital expenses as well as operation and maintenance costs, wastewater treatment plants (WWTP) continue to be one of the key investments for the second WWMS component, wastewater treatment [2,8,9]. Because of this, limited local budgets or funding make it impossible to build new, adequate and cost-effective treatment facilities. This is especially true for decentralized systems, which are more cost-effective and simpler than centralized systems, which require significant capital investments for sewer systems and pumping costs, which account for more than 70% of total annual budgets [10–12]. Modern wastewater treatment should aim to protect the environment and waters, so domestic wastewater is typically collected in sewage systems and treated in a central WWTP, and industrial wastewater is frequently treated at the source in a decentralized WWTP or central WWTP on the premises of an industrial platform, collecting all industrial effluents [13]. Typically, centralized systems collect and treat large volumes of wastewater for entire large communities, industrial/residential platform sites, and other locations (using large pipes, pumping systems, various access routes, constructions, equipment, and treatment facilities/adequate technologies, far from the wastewater generation source), as opposed to decentralized systems that separately collect, treat, and dispose of, or onsite reuse, the treated wastewater at, or near, the generation source. Therefore, treating wastewater as close to its source as feasible and avoiding the need to build broad and frequently expensive sewage lines makes greater economic and ecological sense [14].

Additionally, as the wastewater issue is a global concern, solutions frequently need to be simple, quick, and economical to execute, as well as flexible enough to allow for the provision of individualized solutions. In most situations, the need and requirement point to decentralized WWMS as the best option. The term "decentralized sanitation and reuse" (DeSa/R) in this context refers to techniques for decentralized wastewater treatment that deliver treated wastewater for technological recycling and/or reuse of wastewater nutrients and other valuable elements. The third WWMS component, treated wastewater disposal, is based on (i) conventional disposal techniques by straightforward evaporation, discharge in surface water, or subsurface soil absorption/adsorption systems, and (ii) reuse techniques by passing through trenches and beds that can be effectively operated in nearly all climates, without electricity, and are less expensive, stocking the treated wastewater in specific receiving basins/collectors, and using it for proper domestic, irrigation, or industrial purposes.

The risk of future issues and failures is being reduced by decentralized systems, which also make it possible to choose the wastewater treatment technology that is economically feasible, environmentally and/or ecologically sustainable, socially acceptable, technically viable, sustainable, and flexible [8,15].

Due to economic and technological changes affecting industrial platform sites, these fundamental approaches and systemic analyses for practical decisions in wastewaters treatment design and related impact on water resources allow to understand and evaluate some concrete real datasets varying in time, which require in-time adoption of various solutions for WWMS, especially various components of wastewater treatment systems, organized to operate in the central location. Since there are few studies on the assessment of the public health risk of OWTS in the study area in particular and the Gaza Strip (Khan Yunis area) in general, this paper's broad objective is to fill that gap. It also addresses the environmental assessment of onsite wastewater treatment in situ by some important variables such as five-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), and faecal coliform (FC). The specific goal is to evaluate the potential risks to the public's health posed by OWTS situated nearby an onsite groundwater supply facility (OGSS), to ascertain how they may affect groundwater quality, constituents of concern (COC) concentrations, reuse of treated wastewater in agriculture, routes of exposure to the target population, and potential health risks.

To improve OWTS designs and technology selection, this risk assessment study recommends the integration of risk assessment-based management decisions that are largely focused on sanitation systems and public health hazards (microbial and chemical) [16].

2. Materials and methods

2.1. Plant description

The Gaza Strip is divided geographically into five governorates: Northern; Gaza; Mid Zone; Khan Yunis; and Rafah, as shown in Fig. 1. Khan Yunis is located in the southern part of the Gaza Strip.

The population of Khan Yunis reached 270,979 inhabitants in 2013 [17]. Khan Yunis municipality consists of the following zones: Krara; Absan Kabera Absan Jadeeda; Alfakhari and Khaza'a. Absan Jadeeda is located in the governorate of Khan Younis, on flat ground, and the land is easily scalable to grow all kinds of crops.

To reuse treated wastewater to irrigate fruit and olive trees that can withstand moderate salinity, the Palestinian Hydrology Group (PHG) installed a treatment unit in a semi-urban region of Khan Yunis in the southern governorate of the Gaza Strip.

The system was built to handle black wastewater treatment and to be used as a potential source for recycled treated wastewater. The system's introduction was intended to improve non-traditional water resource utilization, safeguard the environment, and lessen the use of cesspits. The system consists of a few fundamental components, including a wastewater collection system, a wastewater treatment facility, and a distribution system that allows the reuse of treated wastewater in fields of olive and fruit trees. The system now receives 14.5 m^3/d from 24 families with an average of 168 individuals, but the unit has a daily treatment capacity of 24.5 m^3 and can service 50 families with an average of 350 members15 dunums of land that is utilized for farming and have olive and fruit trees are watered with the treated wastewater. A septic tank, a trickling filter sedimentation tank, and a sand filter next to the collecting tank make up the wastewater treatment unit. As depicted in Fig. 2, the first treatment involves a septic tank and, and the secondary treatment involves a trickling filter and sand filter.

Quality measurements were conducted through Coastal Municipalities Water Utility (CMWU) lab in cooperation with PHG, the main parameters are shown in Table 1 on 1st July 2012.

2.2. Sampling and analysis

To collect wastewater and track how much entered the facility, a sewage system was established for the semi-urban area's population. Grab sampling or composite sampling are the two procedures that are typically used for wastewater sampling. Grab sampling is exactly what it sounds like; the entire sample is gathered all at once. As a result, a grab

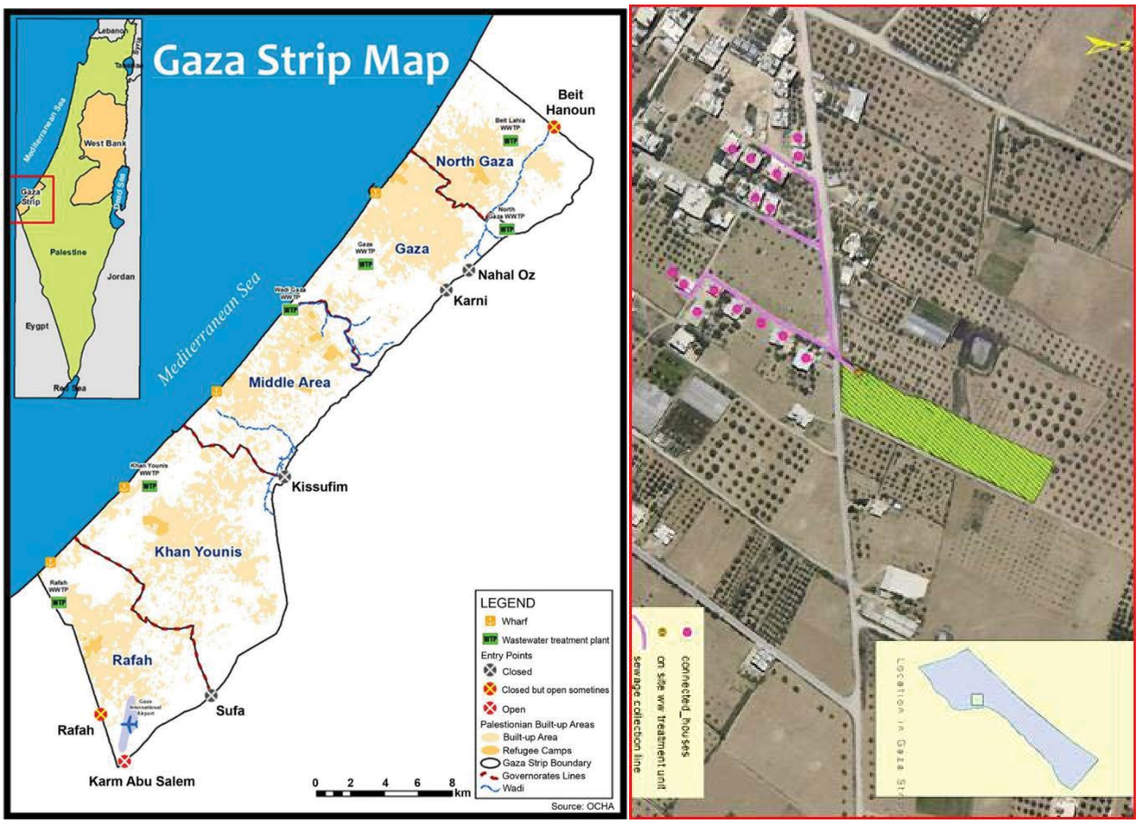

Fig. 1. Khan Yunis study area.

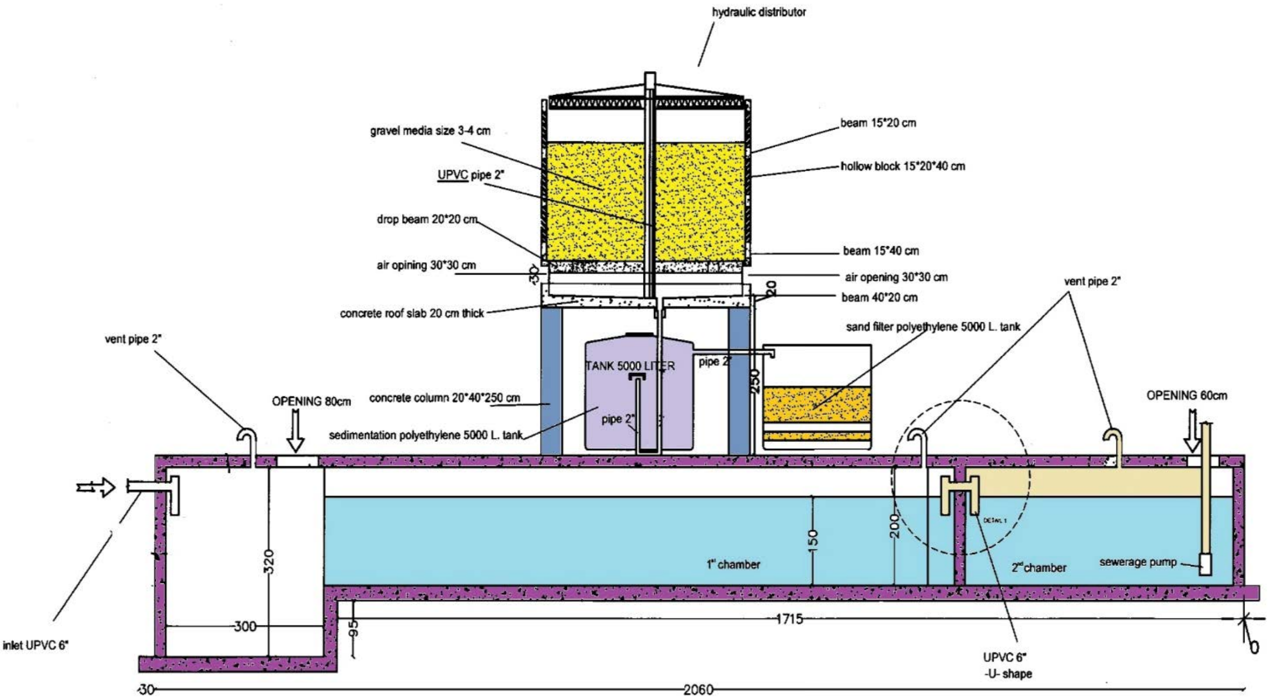

Fig. 2. Treatment unit tanks.

Table 1
Values of the main parameters influent to the system

Five-day biochemical oxygen demand	220 mg/L
Chemical oxygen demand	470 mg/L
Suspended solids	110 mg/L
Total Kjeldahl nitrogen	126 mg/L
Faecal coliform	2×10^8

sample only accurately captures performance at the time it was taken, and only if it was taken properly. A composite sample is made up of several discrete samples that were all taken separately and at regular interval sometime of time, often 24 h. Over the course of the sampling period, the substance being sampled is gathered in a shared container. Therefore, the analysis of this data, which was some time a period of time, will represent the typical operation of a wastewater treatment plant during the data collection period.

Numerous industry publications describe different parameters for evaluating wastewater as well as whether grab sampling or composite sampling procedures should be used for sample collection. Grab sampling, for instance, enables the measurement of particular classes of volatile parameters like pH, dissolved oxygen, chlorine residual, nitrites, and temperature. However, the use of composite sampling techniques is necessary for the most commonly used indicators of treatment plant performance, such as BOD_5, COD, TSS, TDS, TN (total nitrogen), and FC.

The only verifiable indicator of treatment plant success is a composite sample of effluent that has been collected, stored, tested, tabulated, and averaged over a long period. It can be costly and time-consuming to gather and analyze these composite samples.

Six samples are taken from the Abasan wastewater treatment system, and an hour composite sample is taken from the influent manhole to the system, effluent from the septic tank, effluent from the trickling filter, effluent from the sedimentation tank, and system effluent that is after the sand filter and screen filter. The average of the test results is then calculated.

The implemented treatment unit consists of a septic tank, trickling filter, sedimentation tank and sand filter, respectively. The system was monitored in the period between May/2013 (after two weeks from the system operating) to Oct/2013 and samples were taken from five locations influent manholes to the system (Loc. 1), the effluent of the septic tank (Loc. 2), the effluent of trickling filter (Loc. 3), the effluent of sedimentation tank (Loc. 4), the effluent of a sand filter and screen filter (Loc. 5) as shown in Fig. 3.

2.3. Evaluation criteria of the system

To investigate the effectiveness and issues with the system, an evaluation study for the operational systems of the onsite wastewater treatment facilities in Khan Younis (Abasan) was carried out.

The system's effectiveness will be measured primarily by a few key metrics that are related to tolerance, feasibility, and efficiency. These indicators must be specified. The following are the most frequently required indications to evaluate the systems.

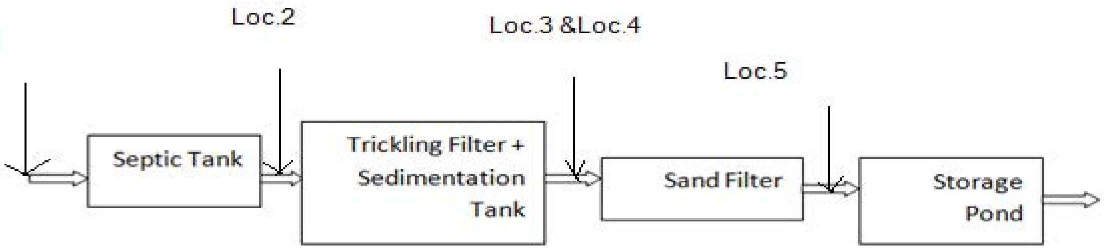

Fig. 3. Places of sampling from the treatment ponds in the wastewater treatment plant.

2.4. Treatment efficiency

To gauge the effectiveness of the system and the quality of the treated wastewater, the effluent will be examined. The technology selected ought to result in an effluent that meets certain quality standards.

$$\text{Efficiency} = \frac{\text{influent quality} - \text{effulent quality}}{\text{influent quality}} \times 100\%$$

2.5. Maintenance and operation

The degree of ability required to operate the system and perform maintenance will be the main subject of evaluation. It is presumable that the systems must be operated and maintained to some extent, and that skilled owners must carry out maintenance and operational tasks as necessary.

2.6. Social acceptance and economic analysis

The project was constructed in a semi-urban region that was polled by the questioner to learn more about the residents' willingness to connect with the system, their family's standard of life, and whether or not the project was better before or after it was operational and agree to fund the system's operation via fees. The cost of the batteries that power the system with solar energy constitutes the operational cost.

3. Results and discussion

3.1. System efficiency

The system that was put in place in Abasan, in the Gaza Strip, to treat household wastewater from homes in semi-urban areas is the subject of the results, which concentrate on examining the technical performance elements of the system. The system was put in place so that wastewater could be recycled and used to irrigate fruit and olive crops in the southern Gaza Strip governorate. A septic tank, trickling filter, sedimentation tank, and sand filter, respectively, make up the treatment unit that has been put into place. As shown in Fig. 3, samples were taken from five locations during the monitoring period of May/2013 (after two weeks of the system operating) to Oct/2013: influent manholes to the system (Loc. 1), the effluent of the septic tank (Loc. 2), the effluent of trickling filter (Loc. 3), the effluent of sedimentation tank (Loc. 4), and effluent of a sand filter and screen filter (Loc. 5).

3.2. System efficiency in BOD removal

The predicted total flow rate to the treatment unit is 14.5 m^3/d, with a BOD$_5$ concentration that ranges from 230 to 520 mg/L on average. BOD$_5$ levels in the flow effluent from the septic tank range from 210 to 480 mg/L on average. The average elimination rate is 14.48%, although the range is 5.7%–38%. With time, the rate of elimination increased.

The trickling filter's effluent BOD$_5$ ranges from 105 to 190 mg/L, with an average of 133 mg/L. The highest efficiency for BOD$_5$ elimination is between 47.62% and 68.18%, with an average of 57.45%. The BOD$_5$ range for the effluent from the sedimentation tank is 10–70 mg/L, with an average of 43 mg/L. With an average of 53%, efficiency ranges from 36.36% to 78.95%.

On July 27, 2013, a sand filter was installed in the system to enhance the effluent characteristics. It comprises of 2 gravel-filled, 1 m^3-sized tanks. The effluent BOD$_5$ ranges from 5 to 80 mg/L, and over time, its effectiveness improved.

The total BOD$_5$ removal rate range for the system is 71.43%–95.65% with an average of 86.1% which also increased with time as shown in Table 2.

The BOD$_5$ concentration for the treatment system is shown in Fig. 4 at various sampling locations and times. It demonstrates that the elimination rises over time as a result of the bacterial cells that grow and quicken the healing process. The tiny population connected to the wastewater network caused a variation in the influent BOD$_5$ values, which increased the effects of the individual on the specifications of influent wastewater as indicated in the measurements from 15/7/2013. On July 27, 2013, a sand filter was added to the system, however, because the sand filter material was leaking some organic waste, the reading after the sand filter was greater than the reading before it. The majority of readings fall within or below the Palestinian Draft Standard (PDS).

3.3. System efficiency in COD removal

The average influent COD content was 861 mg/L, with a range of 695–1,050 mg/L. The COD range for the effluent from the septic tank is 605–1,000 mg/L, with an average of 801 mg/L. The average removal rate is 7.41%, with a range of 4.76%–12.95%. The trickling filter's effluent COD has an efficiency range of 52.07%–66.9% with an average of 60.49%, ranging from 290 to 331 mg/L on average. The effluent from the sedimentation tank has a COD range of 120–150 mg/L with an average of 131 mg/L. The efficiency grew over time and is now the highest efficiency for COD removal. With an average efficiency of 56.49%, the efficiency ranges from 48.98% to 63.44%. The system's overall COD removal rate ranges from 80% to 88.48%, with an average of 84.11% that grew over time as indicated in Table 3.

The correlation between COD and the length of time spent in treatment procedures throughout the monitoring period is shown in Fig. 5. The tiny population connected to the wastewater network caused a variation in the influent COD readings, which increased the effects of the individual on the specifications of influent wastewater as demonstrated by the high readings from July 15, 2013, as shown in Fig. 5.

Fig. 6 shows how the COD curve's trend resembles the BOD_5 trends curve, which depicts the impacts of bacterial stabilization. The typical COD/BOD_5 intervals range from 2.22 to 2.95, with a mean of 2.63.

3.4. System efficiency in TSS removal

With an average of 389 mg/L, the TSS content in the influent varies from 90 to 1,200 mg/L. The range of the TSS in the effluent from the septic tank is 70–805 mg/L, with an average of 329 mg/L and a clearance rate of 5.4%–32.92% (on average, 16.41%). With an efficiency ranging from 42.62% to 88.82% and an average of 51.53%, the trickling filter's effluent TSS ranged from 70–140 mg/L with an average of 94.6 mg/L. The TSS range for the effluent from the sedimentation tank is 14–65 mg/L, with an average of 38 mg/L. With an average efficiency of 57.55%, the efficiency ranges from 27.78% to 85.26%. The TSS in the sand filter's effluent ranges from 12 to 30 mg/L. According to Table 4, the system's total TSS efficiency ranges from 64.44% to 96.76% with an average of 85.7%.

The correlation between TSS and the length of time spent undergoing treatment throughout the monitoring period is shown in Fig. 7. The tiny population connected to the wastewater network caused a variance in the influent TSS readings, which increased the influence of the individual on the specifications of influent wastewater as seen by the readings taken on 15/7/2013. The majority of measurements fall within or below the Palestinian Draft Standard (PDS) for water reuse (40 mg/L).

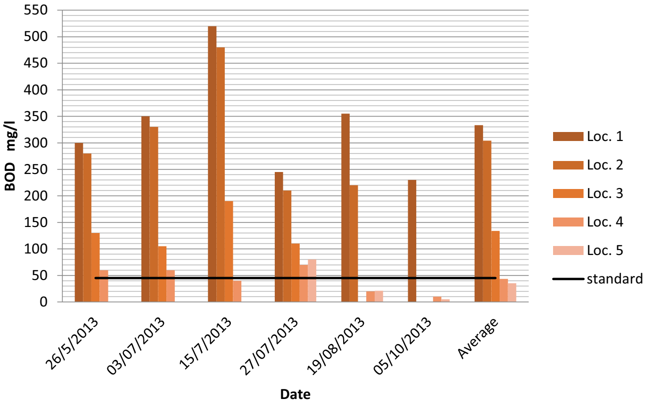

Fig. 4. Biochemical oxygen demand removal for every treatment stages.

Table 2
Characteristics of influent and effluent of biochemical oxygen demand system

Date	Biochemical oxygen demand (mg/L)					Standard	Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5		Septic tank	Trickling filter	Sedimentation tank	Total efficiency
26/5/2013	300	280	130	60		45	6.67	53.57	53.85	80.00
03/07/2013	350	330	105	60		45	5.71	68.18	42.86	82.86
15/7/2013	520	480	190	40		45	7.69	60.42	78.95	92.31
27/07/2013	245	210	110	70	80	45	14.29	47.62	36.36	71.43
19/08/2013	355	220		20	21	45	38.03			94.37
05/10/2013	230			10	5	45				95.65
Average	333.33	304.00	133.7	43.33	35.3	45	14.48	57.45	53.00	86.10

Table 3
Characteristics of influent and effluent of chemical oxygen demand system

Date	Chemical oxygen demand (mg/L)				Standard	Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4		Septic tank	Trickling filter	Sedimentation tank	Total efficiency
26/5/2013	695	605	290	135	150	12.95	52.07	53.45	80.58
03/07/2013	750	700	294	150	150	6.67	58.00	48.98	80.00
15/7/2013	1,050	1,000	331	121	150	4.76	66.90	63.44	88.48
28/07/2013	950	900	315	120	150	5.26	65.00	61.90	87.37
Average	861.25	801.25	307.50	131.50	150	7.41	60.49	56.94	84.11

3.5. System efficiency in TDS removal

TDS is not impacted by different treatment components, as demonstrated in Table 5 and Fig. 8, as long as the values are less than the Palestinian Draft Standard (PDS) for water reuse (1,500 mg/L).

3.6. System efficiency in FC removal

The FC influence on the system range is 50 × 10^3–20 × 10^6 CFU/100 mL with an average of 4.04 × 106 CFU/100 mL, then the flow effluent from the septic tank with FC range of 10 × 10^3–1.5 × 10^7 CFU/100 mL with an average of 3.8 × 10^6 CFU/100 mL.

The effluent FC from the trickling filter is 2.2 × 10^4 CFU/100 mL. The sedimentation tank has FC effluent range of 920–1.1 × 10^4 CFU/100 mL with an average of 1.8 × 104 CFU/100 mL. The FC range is 640–1.1 × 10^4 CFU/100 mL with an average of 4,247 CFU/100 mL after the sand filter.

According to Table 6, the system's overall FC efficiency ranges from 38.89% to 99.81%, with an average of 74.96% that grew over time.

The outcomes also demonstrate that, after the addition of the sand filter, the system's efficiency increases to go below the Palestinian Draft Standard (PDS) for water reuse (1,000 CFU/100 mL).

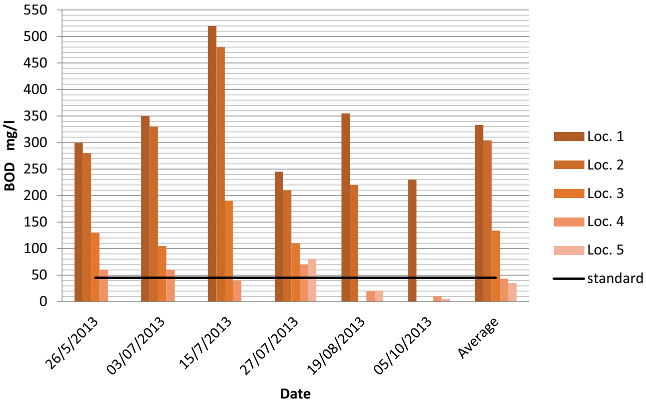

Fig. 5. Chemical oxygen demand removal for every treatment stages.

3.7. Modification of the system for actual results compared with design

The conceptual design of the treatment unit was based on theories and experiments, and after the unit's operation, samples were taken to ensure its efficacy and compatibility with the conceptual design. However, these samples weren't the same, so this should be considered, and the necessary modifications should be made.

The wastewater from 50 families will be treated at the treatment facility. Table 7 provides an estimate of wastewater production; however, Fig. 9 shows the actual usage.

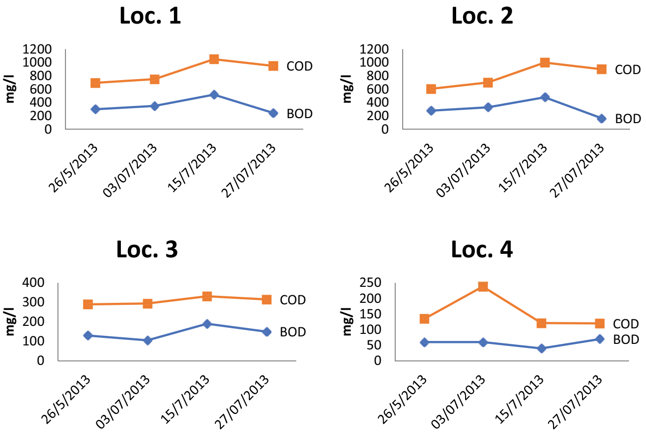

Fig. 6. Values of five-day biochemical oxygen demand and chemical oxygen demand.

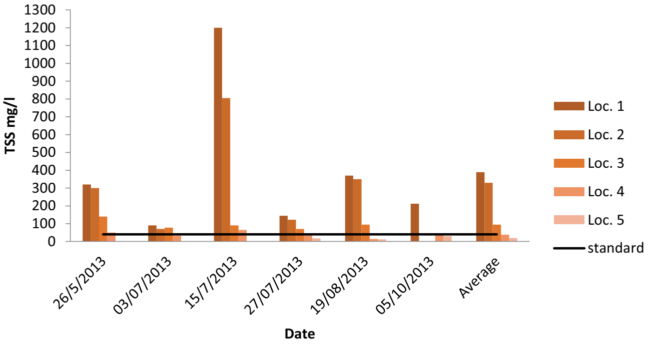

Fig. 7. Total suspended solids removal for every treatment stages.

Table 4
Characteristics of influent and effluent of total suspended solids system

Date	Total suspended solids (mg/L)					Standard	Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5		Septic tank	Trickling filter	Sedimentation tank	Total efficiency
26/5/2013	320	300	140	50		40	6.25	53.33	64.29	84.38
03/07/2013	90	70	78	32		40	22.22	0.00	58.97	64.44
15/7/2013	1,200	805	90	65		40	32.92	88.82	27.78	94.58
27/07/2013	144	122	70	34	17	40	15.28	42.62	51.43	88.19
19/08/2013	370	350	95	14	12	40	5.41	72.86	85.26	96.76
05/10/2013	212			35	30	40				85.85
Average	389.33	329.40	94.60	38.33	19.67	40	16.41	51.53	57.55	85.70

After the tests, the actual results are shown in Table 8.

The system's effluent BOD_5 should be 44 mg/L according to design, but tests only indicate 35 mg/L. BOD_5 is removed at a rate of 85.3% in the design, but its average actual removal rate is 86.1%. System failure and inactivity for almost two weeks were followed by repairs and the addition of a sand filter. BOD_5: 25 mg/L, FC: 103 CFU/100 mL, suspended solids (SS): 30 mg/L; effluent BOD_5, COD, TSS, TDS, and FC concentration better than treatment plant design criteria and near or lower than WHO standards for non-restrictive irrigation. When compared to the design, the actual outcomes are better.

3.8. Social acceptance

The main sewerage network has been constructed, and the populace has agreed to connect to it and pay a fee to utilize it for the plant's operation. In three streets on the map in Fig. 10 connected to the system are 24 families, totalling 168 beneficiaries.

The system's sustainability depended on community involvement, which was made sure of through in-depth interviews with the community and municipality and the formation of the project management committee, which was made up of system users and operators and was suggested by the project after a feasibility study of the system's

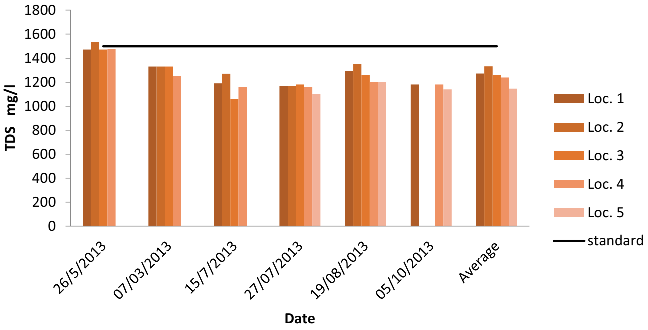

Fig. 8. Total dissolved solids removal for every treatment stages.

Table 7
Actual wastewater quantities

Description	No.	Unit
Number of families	24	Family
Inhabitants per family	7	persons
Total population	168	persons
Wastewater production	85	L/C/D
Average wastewater	14.28	m^3/d
	0.16	L/S

Table 5
Characteristics of influent and effluent of total dissolved solids system

Date	Total dissolved solids (mg/L)					Standard	Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5		Septic tank	Trickling filter	Sedimentation tank	Total efficiency
26/5/2013	1,472	1,536	1,472	1,478.4		1,500	0	4.17	0.00	0.00
07/03/2013	1,330	1,330	1,330	1,250		1,500	0	0.00	6.02	6.02
15/7/2013	1,190	1,270	1,060	1,160		1,500	0	16.54	0.00	2.52
27/07/2013	1,170	1,170	1,180	1,160	1,100	1,500	0	0.00	1.69	0.85
19/08/2013	1,290	1,350	1,260	1,200	1,200	1,500	0	6.67	4.76	6.98
05/10/2013	1,180			1,180	1,140	1,500				0.00
Average	1,272	1,331.2	1,260.4	1,238.0	1,146.6	1,500	0.0	5.47	2.49	2.73

Table 6
Characteristics of influent and effluent of faecal coliform system

Date	Faecal coliform (CFU/100 mL)					Standard	Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5		Septic tank	Trickling filter	Sedimentation tank	Total efficiency
26/5/2013	20×10^6	1.5×10^7		3.8×10^4		1,000	25	100.00		99.81
15/7/2013	1.8×10^4	2.4×10^4	2.2×10^4	1.1×10^4		1,000	0	8.33	50.00	38.89
27/07/2013	1.8×10^4	2.4×10^4	2.2 × 10=	1.1×10^4	1.1×10^4	1,000	0	8.33	50.00	38.89
19/08/2013	50×10^3	$10 \times 10_3$		920	1.1×10^3	1,000				97.80
05/10/2013	1.1×10^5			2.7×10^4	640	1,000				99.42
Average	4.04×10^6	3.8×10^6	2.2×10^4	1.8×10^4	4,246.67	1,000	8.33	38.89	50.00	74.96

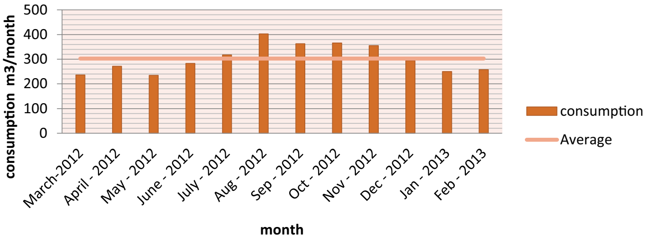

Fig. 9. Actual consumption for studed area in 1 y.

Table 8
Actual results

Five-day biochemical oxygen demand	333 mg/L
Chemical oxygen demand	861 mg/L
Total suspended solids	389 mg/L
Faecal coliform	4.04 × 10^6 CFU/100 mL

Fig. 10. Abasan area map and sewage system.

operating costs. Each family should contribute 15 NIS per month to run the system. Data gathered from questionnaires given to the 24 households in the project area at the start of the project is used in community surveys.

15 dunam planted with fruit trees (citrus, olive, peach, apple, and cactus) are watered with production effluent. A farmer needs 5 m^3 of water per dunum each day. After the testing produced satisfactory results, the farmer immediately agreed to build the project on his property, support it, and use wastewater production satisfaction.

The rates charged to operate the treatment unit connectors are much less expensive than what residents used to pay to empty cesspits. Although the population that was linked to the network agreed to pay the fees, they did not because there was no formal entity in charge of collecting the money and the majority of them had poor living conditions.

4. Conclusions

Most semi-urban and/or rural areas are now required to implement an onsite wastewater treatment system (OWTS), which raises significant economic, social, technical, and environmental issues that must be considered (e.g., funding, workers' involvement and awareness, appropriate system design and selection of efficient processes, proper inspection, monitoring and evaluation program of environmental components).

The conservation of environmental quality, the reduction of natural aquatic environment pollution, and environmental safety and public health continue to be major responsibilities of WWTPs. The implementation of a cost-effective WWTP, selection of the most suitable or pertinent wastewater treatment technology, and wastewater treatment system operation and maintenance including operational improvements, long-term repairs and replacements needed in the future, all depend on an understanding of the stability and importance of natural aquatic receptors.

Following four months of system monitoring and analysis of BOD_5, COD, TSS, TDS, and FC. The rates of BOD_5 elimination in the septic tank, trickling filter, sedimentation tank, and sand filter all exceeded 14.5%, 57.5%, 53%, and 18.46%, respectively. 86% of BOD_5 has been removed altogether. The COD removal rates in the sedimentation tank and trickling filter each reached 57%, 60.5%, and 7.5%, respectively. 84% of COD has been removed altogether. The TSS removal rates in the septic tank, trickling filter, sedimentation tank, and sand filter all exceeded 16.5%, 51.5%, 57.5%, and 48.6%, respectively. 85.7% of the TSS was removed in total. The FC removal rate was achieved at 8% in the septic tank, 39% in the trickling filter, 50% in the sedimentation tank, and 75.85% in the sand filter. 75% of FC has been removed overall.

On the other hand, the treated wastewater quality is acceptable for the direct irrigation of olives and fruit according to Palestinian standards. The average of the past two tests, which included a sand filter for FC, was greater than the Palestine norm. OWTS was expected to have an operating cost of 15 NIS per family as opposed to 50 NIS for empty cesspits. Residents embrace the system socially because no raw sewage disposal is done. The system is adequately run by the landowner, who is also interested in increasing the number of home-connection units. SAT, reed bed systems and cesspits have all been tested for the disposal of wastewater in the Gaza Strip. It is still necessary to look into more sustainable techniques for the treatment and disposal of wastewater in semi-urban areas since none of these trailed systems is long-lasting.

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