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Investigation on utilizing garbage as a resource for a sustainable neighbourhood: Case study of a neighbourhood in New Cairo, Egypt

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Abstract. Waste management comprises the actions required for managing waste material produced from human activities from its source of origin to its final removal. Usually, it collects resources from all forms of matter such as gaseous, liquid, solid, and radioactive. This action is made to avoid the negative effects of wastes on the environment and human wellbeing. The effect of accumulating waste may be highly severe for numerous communities in developing countries such as Egypt. Egyptian neighbourhoods suffer from effects of accumulating local wastes and garbage. Public health and the visual image of the neighbourhoods, in addition to the different social, economic, and environmental aspects of life are also harmed. In Egypt, this issue becomes more challenging because the defined policies for waste managementare yet in their dawn stage and hence, results are not yet as anticipated, which inflicts severe environmental hazards on Egyptian communities and drains a large portion of the local economy. This study aims to propose a technique to manage the organic waste in Egypt by storing them in anaerobic digesters which turns the wastes into electricity and biogas. It will focus on investigating current social and environmental aspects of the neighbourhood, to determine if this proposal will be appropriate as a solution for getting rid of organic wastes and generate energy, in order to create sustainable neighbourhood. A questionnaire took place revealing that using anaerobic digesters will help the Egyptian government in solve one of its major challenges which is getting rid of neighbourhood's wastes which decreasing the level of pollutions and epidemics especially in low income districts.

Keywords: Egyptian neighbourhoods, organic wastes, anaerobic digesters, sustainable neighbourhood, biogas

1. Introduction

Waste management comprises gathering, transportation, removal or reutilizing and monitoring of wastes produced from human activities for avoiding related opposing consequences on the environment and human wellbeing. Waste management has become a complicated field, officially, technically and commercially. Only low income societies are still depending on the waste gathering services provided by local authorities, unfortunately Egypt is one of this societies [1]. In Egypt, the problem of waste has become one of the daily problems facing the citizens. The increasing rate of garbage and its encirclement of gathering places such as schools and hospitals has become a threat to a serious environmental disaster and a good atmosphere for increasing the epidemics as the government continues to fail to deal with that problem. In addition to that, there is a poor environmental awareness between the Egyptian citizens who has contributed to the worsening of the crisis. Getting rid of these wastes is an issue that worries the decision makers and the scientists who seek to deal with

environmental security and reduce the environmental and health risks that this waste can cause, which threatens the future of the new generations [2]. Due to the lack of clear waste management strategy, today one of Egypt's biggest problems that faces the Egyptians, is the burning of rice straw, which causes what is known as the black cloud. Every year Egyptians suffer from the black cloud, which produced after the harvest season of the rice crops affecting public health in several ways [3 & 4]. Usually, the types of wastes come in liquid or solid states. Both could be dangerous. Liquid and solid waste categories can also be gathered into organic, re-utilizable and recyclable waste.
This research will focus on investigating the public acceptance of using anaerobic digesters toward creating sustainable neighbourhoods. The research will also study the environmental impact of inserting the neighbourhood organic wastes in anaerobic digesters. It is considered as the first stage of a greater research that will study the economic feasibility of anaerobic digester system in the same neighbourhood.

1.1. Anaerobic Digesters
Anaerobic digesters are used in various environments where agricultural or manufacturing procedures generate an important organic waste stream [5]. Anaerobic digesters make numerous influences to climatic change extenuation, as digesters capture biogas that is discharged as the nature of organic waste management at the facility where the digester is in operation [6; 7 & 8]. Another advantage of anaerobic digester is it displaces the fossil fuel based energy, which takes place when biogas is utilized for producing heat or electricity [9 & 10].

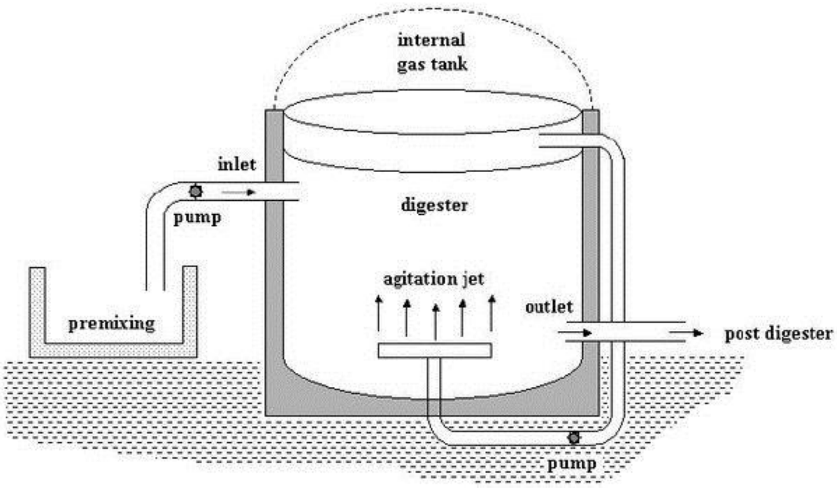

Figure 1. Biogas system including the anaerobic digester [11].
There are varied sorts of anaerobic digesters, all performing the main function of holding compost in the absence of oxygen (O_2) & maintaining the appropriate conditions for methane forming microorganisms for growing in a subtly different way for producing biogas [12 & 13]. These sorts include liquid, slurry, and solid waste anaerobic digesters. They consist of the following main components Fig. 1: mixing tank, feed inlet pipe/tank, digester, gasholder, slurry and gas outlet pipes and tanks. [11; 14 & 15].

1.2. Energy Produced from of Anaerobic Digesters:
The idea of using biogas resulting from domestic activities is not a novice at all. In fact dating back to 1895, UK utilized the biogas that produced within the fermented sewage water of the city of Exeter to operate the streetlights, and this even was not the first time worldwide [16].
Biogas produced from digesters is a non-toxic and colourless and has the scent of natural gas and flame velocity at ignition-35 cm/sec, which is slower than natural gas-this makes it a safer alternative, and the resulting thermal energy ranges from 5000 to 6000 kcal per cubic meter [17; 18 & 19].

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Previous research related the amount of biogas resulting from different harvest yield of crops such as maize or grassland to the amount of electricity that can be generated and hence to the approximate number of households that can be supplied [20]. Furthermore, studies showed some practical applications proving that one cubic meter of biogas could cover any of the following needs [18]:
-Run a burner with medium flame for 2 to 3 hours or a medium-sized oven for 2 hours.
-Operate an internal combustion machine capable of 1 horse for 2 hours.
-Operate of a 10-feet refrigerator for 1-2 hours.

1.3. Case study using anaerobic digesters
Different case studies used the anaerobic digester system to get rid of the organic wastes for creating sustainable urban neighbourhood.

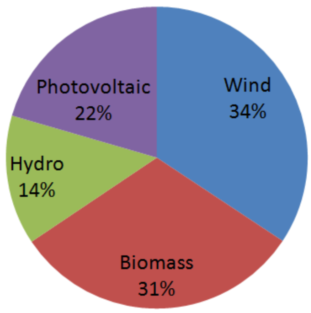

Figure 2. Electricity production from renewable energy sources in Germany (overall 151 TWh) [20]

One of the leading countries in biogas production is Germany Fig.2, as it has the largest number of anaerobic digesters in the world; boosted by political provision, Germany biogas energy economy accounts for approximately 1/4 of the total worldwide installed capacity. Experts of international data believe this tendency to be continued, as the power generated from biogas in Germany is expected to reach 28,265 GWh in 2025 [21].
Since anaerobic digestion is an actual cost-effective process of the treatment of organic wastes as the produced biogas can be utilized for heat, electricity, &fertilizer, anaerobic digesters in Germany are increasing in number [20 & 21].

2. Study area:
The proposed study area is located in New Cairo, 5th settlement, near the city hall of New Cairo city. New Cairo city is located in the east arch of Cairo east of the ring road in the distance between the Cairo-Suez Desert Road and the Katameya-AinSokhna road [23].

Figure 3. Map of the case study context

The case study area is 96,393 square meters. The area is mainly a residential area of the New Cairo city in addition to a school which is the Al-Farabi school. The area is surrounded by different types of buildings; residential, educational (Siza El-Nabarawy girl's school), religious (Quds Mosque) & services (police & fire station), as shown in Figure 3.

3. Methodology and procedures

The procedures of the research initiated with search the literature on the topic anaerobic digesters, & how they work, their components, and the different types of the digesters. Then, the research discussed different types of wastes and how they can feed digesters to produce clean energy. Next, a case study of Germany was presented to identify how much electricity and biogas are generated. Finally, a questionnaire was made for identifying the effect of anaerobic digesters toward the social acceptance. Moreover, the research measures the effect of using anaerobic digesters toward carbon emission reduction.

The research method used is a qualitative questionnaire. The Questionnaire was chosen to be the method for data collection because the study aims at measuring the amount of wastes produced from Egyptian neighbourhoods as a preliminary investigation for studying the effect of anaerobic digesters toward creating sustainable city. This research will focus on the social and environmental effect of using anaerobic digesters systems in Egypt. The use of anaerobic digesters will produce amounts of biogases, heat & electricity will be calculated in future research. The Questionnaires are divided into two phases; the first phase is a questionnaire targeting the neighbourhood garbage cleaners, while the second phase targeted the neighbourhood residents.

3.1. Characteristics of Participants:

The research participants were divided into two types which are: cleaners, & neighbourhood residents. A total of 150 persons participated in this research and were surveyed during March 2018. The sample included 20 cleaners of Fifth-Settlement, who were interviewed. While, 130 participants were randomly selected amongst the neighbourhood. The distribution of the participant's social and demographic characteristics, such as gender, age, is shown in Table 1 & Table 2.

Table 1. Gender of participants

Gender	Percentage
Male	91.6%
Female	8.4%

Table 2. Age range of participants.

Age	Percentage
Below 20	5%
20-29	20%
30-39	20%
40-49	35%
Above 50	20%

3.2. Data collection:

In this research, questionnaires were chosen to be the method of data collection because the study was aiming to estimate percentages of organic wastes produced from Egyptian neighbourhood and the social and environmental effect of using anaerobic digesters in Egyptian urban settlements as an initial step prior to quantifying these results to calculate the resulting energy.

Two types of questionnaires were designed. The first questionnaire targeted the garbage cleaners and it is a short questionnaire consisting of 8 questions aiming to nature of the waste materials in this particular neighbourhood and check percentages of organic materials to determine feasibility of feeding an anaerobic digester system. Also, it investigates the impact of garbage collection process on the cleaners. The second questionnaire targeted the neighbourhood residents and it consists of only 3 simple questions aiming to investigate the social understanding of the negative impact of garbage accumulation in Egyptian neighbourhoods.

The questioning process was simple as the residents group were educated, & easily understood & answered the questions. On the other hand, the interview of the cleaners was more complicated due to the relatively high percentage of uneducated participants and the variety of ages as shown in Table 2.

4. Results

The result section is divided into two phases. Phase one, introduces the results of the effect of anaerobic digesters the social aspects, using statistical analysis for the data which was collected during the qualitative survey. While phase two, introduce the effect of the anaerobic digesters toward the environmental aspects.

4.1. Phase one: The effect of anaerobic digesters on thesocialaspects

The results of this section are divided into two parts. The first part is targeting the cleaners who collect garbage from the chosen neighbourhood. The second part is targeting the residents of the chosen neighbourhood.

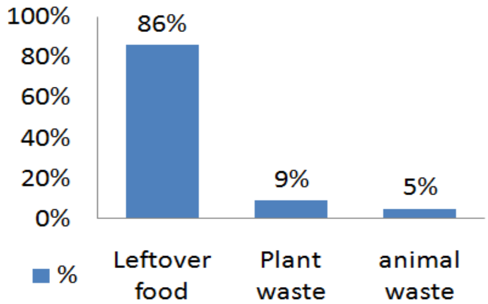

Figure 4. Percentage of organic material types in the garbage

According to the questionnaire with the neighbourhood cleaners it was noticed the following: 86% of the resident's garbage are leftover food while 9% are plants waste and only 5% are animal and insects waste as shown in
Figure 4.

Moreover, the questionnaire revealed that More than 50% of the cleaners agreed that the percentage of organic waste in daily garbage bags is between 61 and 80%.

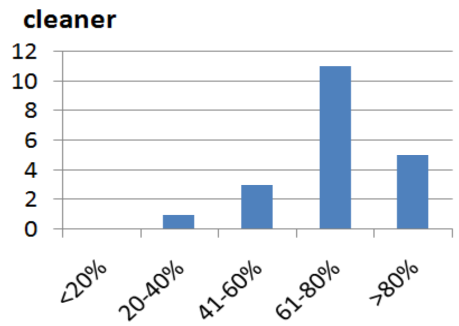

Figure 5. Percentage of organic waste in the garbage

While the cleaners all agreed that, it is very rare to find a garbage bag with less than 20% organic wastes. 5 of the cleaners (almost quarter the sample) stated that the garbage bags has more than 80% organic wastes which indicate the high percentage of organic wastes in the garbage bags coming from this residents in the study area as shown in Figure 5.

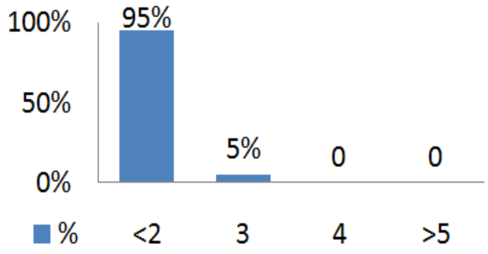

Figure 6. Quantity of garbage vehicles transporting garbage from this neighbourhood

Almost all the cleaners agreed that only one vehicles transport the waste daily from New Cairo district to waste dump which is located in “Katameya” district as shown in Figure 6.

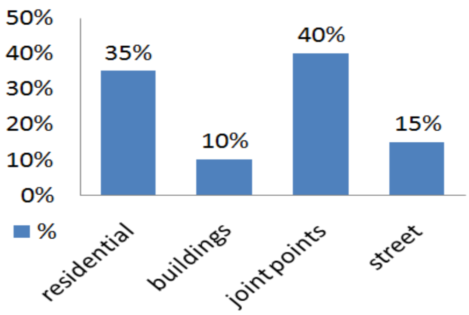

Figure 7. Location of garbage collection

The result show that the majority in this neighbourhood accumulate the garbage 'decently' in bags following a system and not throwing it in the street as shown in fig. 7. This could well be a good start to introduce garbage segregation into organic and inorganic wastes.

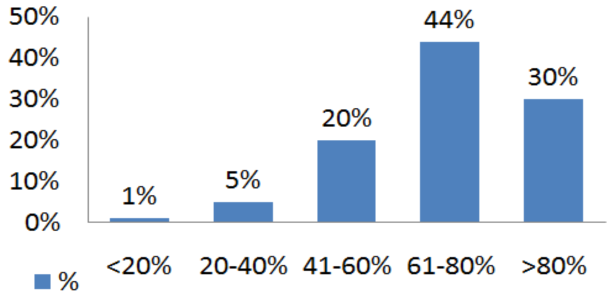

Figure 8. Percentage of organic waste inside the garbage vehicles

As shown in
Figure 8, 44% of the cleaners stated that the percentage of the organic waste in New Cairo districts is between 61 and 80% while 30% stated that the organic waste in garbage vehicles is more than 80%.

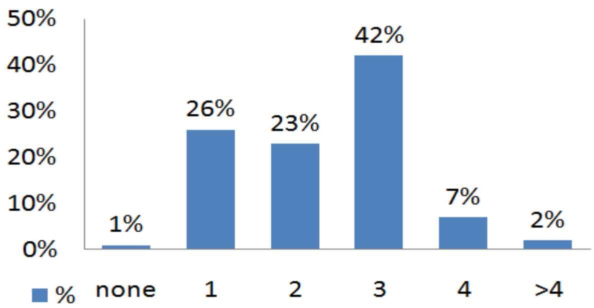

Figure 9. Number of sick leaves per month

This asserts feasibility in terms of quality of using this garbage as a feed to anaerobic digesters. It was notice during the survey that most of the cleaner are taking too much sick leaves as shown in Figure 9, which is an indicator that there job is effecting their health and it helps in spreading the diseases. Moreover, it effects their economic stated which they cannot afford losing their daily payment.

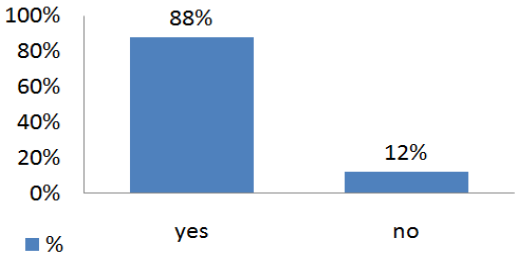

Figure 10. Percentage of cleaners suffering from permanent diseases

The cleaners were asked if they were suffering from permanent diseases, were 88% stated they are suffering from colic and diarrheal, as well as dizziness and chest pain as shown in Figure 10.

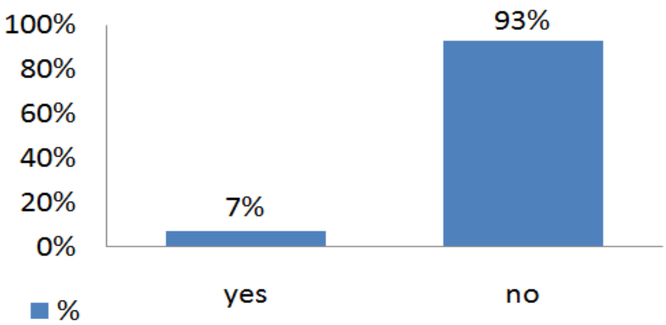

Figure 11. Prospected career path of cleaners

Almost all cleaners stated clearly that they are not willing to continue working in this job and they are willing to shift their career as soon as a new vacancy shows up as show in Figure 11.

Part two of the survey took place between the neighbourhood residents and the results of the survey are shown below:

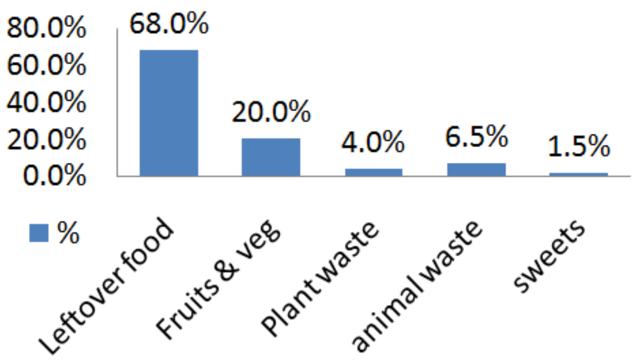

Figure 12. Types of organic wastes in garbage bags

According to the survey, the residents of New Cairo districts get rid of 7 to 10 garbage bags per week. Regarding to the type wastes, the residents' responses were consistence with the cleaners as shown in Figure 12. They both stated that more than 65% of the garbage are leftover foods which is an ideal material for generating energy using the anaerobic digesters, especially that they are not used in any other manufacturing process.

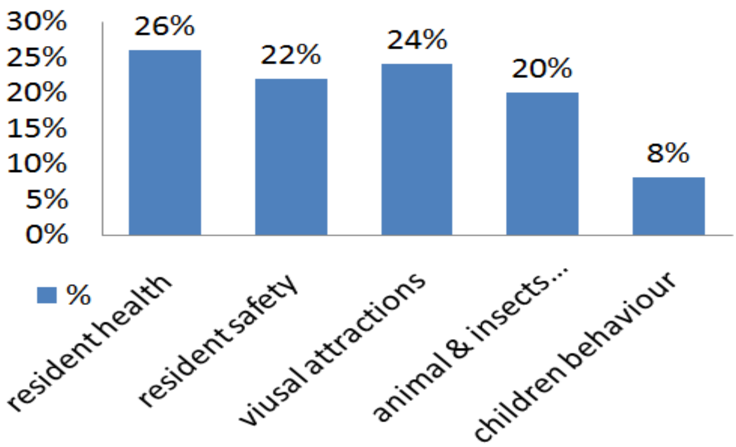

Figure 13. Negative impacts of wastes on the neighbourhood

Moreover, the residents stated that throwing the waste in the neighbourhood streets effect negatively their public heath as well as the neighbourhood image and it attract the wild animals and insects with effect the residents safety as shown in Figure 13.

4.2. Phase Two: The Environmental impact of using anaerobic digesters in Egyptian urban settlements

According to previous studies 1kg of organic wastes produces approximately 0.04m^3 of biogas, so as to produce 1m^3 of biogas, a total of 25 kg is required. 1m^3 of biogas can produce approximately 5kWh [20].

According to this study, the preliminary survey showed that the neighbourhood produces an average of approximately 1260 kg of organic waste per day, which can produce approximately 252 kWh/day

Since that the power station in Egypt is using natural gas to generate energy and provided electricity the community. Each kWh produced from the power station generates an average of 1.22 pounds of CO_2 as shown in Table 3.

Table 3. The amount of CO_2 emission produced from different fuels [23]

Type of Fuel	Pounds of CO_2 per KWh
Bituminous	2.07
Sub bituminous	2.16
Lignite	2.17
Natural Gas	1.22
Distillate oil	1.64
Residual oil	1.76

According to table 3, each kWh produced from natural gas produces 1.22 pounds of CO_2

$\because$ 1 b (pound) = 0.4536 kg

$\because$ The carbon emission produced from Natural gas= 1.22 b/kWh

$\therefore$ CO_2 =1.22×0.4536 = 0.5534 kg/kWh

$\therefore$ The carbon emission reduced daily from using the anaerobic digesters = 252 x 0.5534 = 139.5 kg/kWh.

5. Discussion

The discussion section linked the results section, which described the effect of the anaerobic digesters on the social and environmental aspects with previous researches, is shown below.

5.1. Socially

The neighbourhood has an important role to play in the creation of capabilities for both individuals & communities for attaining a high quality of life (QOL), & bring about their potential for personal growth within the parameters of a sustainable and low carbon lifestyle.

The clean neighbourhood that can be achieved by applying the digester system will affect the economy, environment, as well as the quality of life of the people in the neighbourhood. Quality of life (QOL) is the wide-ranging well-being of people & communities, combining negative & positive features of life. It highlights life satisfaction, comprising everything from physical health, family, education, employment, wealth, religious beliefs, finance and the environment [24]. For instance, by the removal of the organic wastes in the area, the visual image of the area can be enhanced through creating green spaces, parks, plazas, waterfronts, landmarks, & public places where people can meet & gather. Moreover, having a healthier neighbourhood create a more secure life for the people, where there is no fear of diseases or infections to be spread.

Moreover, the amounts of garbage in the streets hindering motion will no more exist, hence, creating a more sociable life to the residents of the neighbourhood.

5.2. Environmentally

The results of the first survey (Cleaners) show that the wastes produced from the neighbourhood are being thrown in the Katameya waste dump, where wastes generally & organic wastes specifically are being burnt which in turn results in air pollution. The survey also showed that more than half the cleaners agreed that organic materials present about 61-80% of their garbage, which emphasizes the suitability of the quality of the waste materials and hence, feasibility of studying the technicalities of implementing the anaerobic digester.

The anaerobic digester system cycle takes about 15 days to produce biogas, which can be used in heating space heating & water heating, it can also be used in stoves, ovens, clothes dryers, lighting fixtures & other appliances like vehicle fuels [25]. This can be done by using a sustainable system that helps in energy generation, through reducing environmental problems such; air pollution that results in climatic change, environmental degradation, natural resource depletion, littering & landfills, where littering means throwing away a piece of garbage or wastes inappropriately at a wrong site, typically on the ground as an alternative to throwing them away at trash container or recycling bin, & landfills on the other side are huge waste dumps that result in the city to look ugly & generate toxic gases that could cause fatal diseases for humans, plants, & animals. Landfills are produced in line for the large amounts of wastes which are produced from households, manufacturing & healthcare centres every day [26].

This results in a clean environment, which in turn results in:

-Saving species which are exposed to the danger of extinction [27]

-Clean air, which in turn results in healthier environment through the reduction of carbon dioxide emissions, & the reduction of fine particles of fumes which causes respiratory and cardiovascular diseases, cancer, asthma and allergies, as well as reproduction and neurodevelopment disorders. Thus, this results in improving the public health of the neighbourhood.

Decrease ozone problem, which serves as the shield of earth from the hurtful ultraviolet B (UVB) radiation emitted from the sun [28], which can cause severe bleeding when inhaled & it can also skin cancer and cataracts in humans and harm animals as well.

Moreover, the study area has no natural gas grid connected to it, so the digester will not only provide electricity to the study are, but also it will provide the area with clean gas needed for cooking & heating with the amounts produced in kilowatts.

6. Conclusion

This article discussed the negative impact that wastes and garbage have on the neighbourhood in terms of social and environmental effects. It proposed the anaerobic digester system that could be incorporated in the Egyptian neighbourhood to play the principle role in minimizing garbage collection activities and wastes exposition in the neighbourhood. The basics of the system were explained and then an international case study from Germany was presented, then the study area was proposed in a district in New Cairo. Questionnaires were conducted with the residents of the neighbourhood and the garbage collectors to investigate the preliminary social acceptance of the idea and determine the nature of the garbage and hence check feasibility of such a proposal. Results showed that the nature of the garbage in the study area is suitable for the anaerobic digester system; moreover, it asserted the negative environmental and health problems from the current waste management system

Thus, this can encourage the community to deal with garbage as a resource and not as a pollutant, so as to result in a cleaner environment. At the same time, it should be highlighted that in addition to the need of studying the technicalities and quantifying the results to declare full feasibility of the proposal, as shall be soon presented as a result of an ongoing study, awareness of the community of the benefits of such initiatives to each and every home is the key to the success so as to change science and experiments into practice and hence, policies.

References

[1] CIPS, (2007). How to develop a waste management and disposal strategy, *Stamford: CIPS*.

[2] El-Qady, H. (2012). *الواقع و الحلول الممكنة, مشكلة المخلفات في مصر*, Cairo: Council of Ministers, Information and Decision Support Center.

[3] Tolba, R.A., El-Shirbeny, M.A., Abou-Shleel, S.M. & El-Mohandes, M.A. (2018). Monitoring and Assessment of Rice Straw Fires in the Egyptian Nile Delta Using Satellite Data. *Conference: 1st International Scientific Conference "Agriculture and Futuristic Challenges"*, At Faculty of Agriculture-Cairo, Al-Azhar University, Nasr City, Cairo, Egypt.

[4] Marey, H.S., Gille, J.C., El-Askary, H.M., Shalaby, E.A.& El-Raey, M.E. (2010). Study of the formation of the "black cloud" and its dynamics over Cairo, Egypt Using MODIS and MISR sensors. *Journal of Geophysical Research*, 115, 1-10.

[5] Zhang, J., Loh, KC., Li, W., Lim, J.W., Dai, Y. & Tong, Y.W.(2017). Three-stage anaerobic digester for food waste. *Applied Energy*, 194, 287–295.

[6] Rajagopal, R., Masse, D.I. & Singh, G. (2013). A critical review on inhibition of anaerobic digestion process by excess ammonia. *Bioresour. Technol*. 143, 632-641.

[7] Fiore, S., Ruffino, B., Campo, G., Roati, C. &Zanetti, M.C.(2016). Scale-up evaluation of the anaerobic digestion of food-processing industrial wastes. *Renew. Energy*, 96, 949-959.

[8] Liu, G., Li, Y., Wang, J., Sheng, H., Li, Q., Zeng, Y.& Song, R.(2018). A comparative experimental study of the anaerobic treatment of food wastes using an anaerobic digester with a polyamide stirring rake or a stainless-steel stirring rake. *Journal of Environmental Management*, 218, 435-441.

[9] Ciolkosz, D. (2013). *Introduction to Biogas and Anaerobic Digestion.* [Online] Available at: http://articles.extension.org/pages/26608/introduction-to-biogas-and-anaerobic-digestion [Accessed 15-12-2017].

[10] Council, A.B. (2010). *What is Anaerobic Digestion?.* [Online] Available at: https://www.americanbiogascouncil.org/biogas_what.asp [Accessed 19-12-2017].

[11] Plöchl, M. &Heiermann, M. (2006). Biogas Farming in Central and Northern Europe: A Strategy for Developing Countries?.Agricultural Engineering International: the CIGR Ejournal, 8, 1-15.

[12] Li, Y.Y., Jin, Y.Y., Li, J.H., Li, H.L. & Yu, Z.X.(2016). Effects of pungency degree on mesophilic anaerobic digestion of kitchen waste. Appl Energy181;171–8.

[13] Zhang, K., Pei, Z. & Wang D.(2016). Organic solvent pretreatment of lignocellulosic biomass for biofuels and biochemicals: a review. BioresourTechnol, 199;21–33.

[14] Graves, R.(2012). *Types of Anaerobic Digesters.* [Online] Available at: http://articles.extension.org/pages/30307/types-of-anaerobic-digesters [Accessed 3 11 2017].

[15] EPA, (2016). . *Types of Anaerobic Digesters.* [Online] Available at: https://www.epa.gov/anaerobic-digestion/types-anaerobic-digesters [Accessed 7 10 2017].

[16] FAQs, the Official Information Portal on Anaerobic Digestion (2019). Available at: http://www.biogas-info.co.uk/about/faqs/ [Accessed 9-7-2019].

[17] Digestion, T. O. I. P. o. A. (2012). FAQs. [Online] Available at: http://www.biogas-info.co.uk/about/faqs/ [Accessed 14 5 2017].

[18] Aradina, (2006). البيوجاز. [Online] Available at: http://aradina.kenanaonline.com/posts/185872 [Accessed 17 12 2017].

[19] Lindmark, J., Thorin, E., Fdhila, R.B. &Dahlquist, E.(2014). Effects of mixing on the result of anaerobic digestion: Review. *Renew. Sustain. Energy Rev.* 40, 1030-1047.

[20] Bundestag, G.(2016). BIOENERGY IN GERMANY FACTS AND FIGURES, Berlin: Fachagenhur Nachwachsende Rohstoffe.

[21] Agency, U. S. E. P. (2017). *Advancing Sustainable Materials Management: Facts and Figures.* [Online] Available at: https://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures [Accessed 1-10-2017].

[22] Authority, N. U. C.(2002). *New Urban Communties Authority.* [Online] Available at: inurl:www.newcities.gov.eg/Default.aspx

[23] EIA (U.S. Energy Information Administration), 2016, How much carbon dioxide is produced per kilowatthour when generating electricity with fossil fuels?, Retrieved January 9, 2017, from https://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11

[24] School, I. B., 2013 . *Quality Of Life: Everyone Wants It, But What Is It?.* [Online] Available at: https://www.forbes.com/sites/iese/2013/09/04/quality-of-life-everyone-wants-it-but-what-is-it/#17b263db635d

[25] King, H.M.(2018). *geology.com.* [Online] Available at: https://geology.com/articles/natural-gas-uses/

[26] Rinkesh, (2009). *Environmental Concerns.* [Online] Available at: https://www.conserve-energy-future.com/top-25-environmental-concerns.php

[27] Sites, G.(2015). *The benefits of a Clean Environment.* [Online] Available at: https://sites.google.com/site/cleaningplanetearth/the-benefits-of-a-clean-environment

[28] THIESSEN, M.(2007). . *Ozone Depletion.* [Online] Available at: https://www.nationalgeographic.com/environment/global-warming/ozone-depletion/