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Mitigating Climate Change Through Energy Recovery at Dandora Wastewater Treatment Plant, Nairobi County, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The world is experiencing an increase in the rate of greenhouse gases emissions accumulating in the atmosphere due to natural and anthropogenic causes. These gasses absorb and emits radiation within the thermal infrared range thus contributing to the Green House effect. The building up of greenhouse gasses beyond the natural acceptable levels can change the earth's climate thus contributing to climate change. To mitigate climate change, there is need to cease the increase of greenhouse gases either by not adding them into the air and or increasing the earths' ability to withdraw them out of air. This study looked into mitigating climate change through energy recovery at Dandora wastewater treatment plant in Nairobi. The study employed both primary and secondary

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data. Operational data on the raw sewer chemical oxygen demand and biological oxygen demand levels was collected from the plant between 2007 and 2013. MS excel was used to analyze the data in order to cipher the trends of biological oxygen demand & chemical oxygen demand loadings and removals and thus estimation of biogas and methane likely to be generated and energy recovery thereof. The relationship between these two variables were tested through a Correlation coefficient test. The two-level computations estimated the daily biogas generation at the treatment plant as 2738m3. The study estimates methane generated to be equivalent to 68398MJ/Day of energy. Considering the calorific value of LPG of 46MJ/kg, this is equivalent to 495 cylinders daily serving 2974 households daily. The findings indicate that recovery of energy from the Plant mitigates climate change through reduction of emissions by 16 tCO2-e per day. The energy recovered had a positive correlation with the emission reduction at a high value of r= 0.99. The study concludes that energy recovery from wastewater treatment plant reduces emission thus mitigates climate change.

Keywords: Climate change; greenhouse gas; energy recovery global warming.

1. INTRODUCTION

The world is experiencing an elevated rate of greenhouse gases (GHGs) brought about by natural and anthropogenic causes. These greenhouse gases blanket the earth, trapping suns heat in the atmosphere and increasing temperatures making it warm, a phenomenon referred to as the greenhouse effect. When the greenhouse gasses build beyond the natural acceptable levels, they can alter the earth's climate thus having negative effects on natural ecosystems as well as on human health.

This study focuses on Methane as a greenhouse gas. The waste sector (Anaerobic waste treatment and main sewer) contributed approximately 9% of total global CH_4 emissions in 2006 (US EPA 2006). Furthermore, the Green House Gas emissions factsheet of 2017 by USAID estimated emissions from agricultural sector as 62.8%, energy sector as 31.2%, industrial processes sector as 4.6%, and lastly waste sector (1.4%) (USAID, 2017). Anaerobic wastewater treatment plant is the main human sources of methane gas which is the focus of my study.

The treatment and technology employed in a wastewater treatment plant dictates the type of greenhouse gas emitted therein. (Letting *et al*, 1999). Effluents from wastewater treatment plants generates methane (CH_4) when treated anaerobically. Biological decomposition of organic matter and pollutants is one of the well-developed methods of environmental conservation through remedial specialty in handling wastes and wastewater [1]. Biogas is the by-product of anaerobic digestion; biogas is a gaseous fuel that is made up of about 60% methane and 40% carbon dioxide [1]. Methane when purified, can serve as an alternative energy source [2]. These greenhouse gases if not collected and recycled will prevent the emission of heat from the earth back into the space. This results in increased temperatures on the Earth’s surface and creating global warming. Due to multidimensional applicability of carbon footprints, there is a huge scope to apply it in the context of Wastewater Treatment Plants in terms of emission control, energy generation, and, credits for bio energy [3].

This study focused on climate change mitigation through energy recovery from a waste water treatment plant. Energy will be recovered through utilization of methane produced from the effluent waste. Methane produced can be utilized for domestic use as green energy instead of the other non-renewable energy sources; but most captivatingly, it will go a long way in ensuring that the greenhouse effect is kept to a minimal.

Sewage management or effluent waste management continues to be a big issue in Kenya, polluting environmental mediums like the air, land and water sources. For instance, given today’s technological development, these effluents can be treated anaerobically and this yields biogas that creates energy [4]. In Kenya, the application of anaerobic digestion has been applied in treating sewage in major towns including the Dandora Waste Water Treatment Plant (DWWTP) in Nairobi. It is evident that DWWTP is one among the largest such treatment plants in Kenya Specifically, due to high population density in Nairobi County, the increasing levels of urbanization, and the enormous amount of waste that is produced in both solid and liquid forms [5].

The total average industrial and domestic effluent waste inflow at the DWWTP may rise to about 250,000 m^3 per day in the year 2025 [5]. This rapid increase in the average effluent inflow at DWWTP is directly proportional to the overall increase in biogas production. Methane in biogas is one of the potent atmospheric pollutants and it's estimated that its global warming potential (GWP) is 21 times more than that of carbon dioxide (CO_2) [6]. Biogas generated at this facility has not undergone any measurement and is released to the atmosphere without being harnessed leading to emission of greenhouse gases and air pollution. For this reason, this study aims to contribute towards the reduction of climate change impacts through energy recovery at DWWTP. The energy generated can be utilized at the community using it for heating as well as cooking purposes.

2. LITERATURE REVIEW

2.1 Greenhouse Gasses

There are fears born out of anthropogenic activities that have modified climate patterns globally. These major concerns include the release of gases such as GHG into the atmosphere. Data shows that in 2013 estimated 60.2 MtCO2e (metric tonnes) of GHGs emissions were recorded in Kenya (GoK,2016). The emissions accounted for 0.13 percent of the total global GHG emissions. The emissions were generated by the following sectors: agricultural sector (62.8%) energy sector (31.2%), Industrial sector (4.6%), and waste sector which contributed 1.4% (Climate links, 2017). According to Parsons et al., [7] methane gas is a significant global warming element causing climate change. In the last 300 years, atmospheric methane increased by about 150%, its average content has increased nearly threefold compared to preindustrial times [8].

2.2 Impacts of Climate Change as a Result of Increase in Greenhouse Gasses

Some of the notable impacts of climate change include rising temperatures and heatwaves [9] melting icecaps and rising see levels [9] altered precipitation patterns and extreme weather events [10] Destruction of ecosystem and biodiversity loss, migration and extinction of species [11] threat of food security and agriculture [10] human health challenges, displacement and migrations, treats to water resources among others[12]. The main challenges experienced in Kenya include extreme weather patterns and threat to food security (GoK,2016).

2.3 Environmental Benefits of Capturing Biogas

Kenya joined the international community in addressing climate change challenges by signing and ratifying the United Nations Framework Convention on Climate Change (UNFCCC) on 30th August of 1994 Kenya. The key objective of the Convention is to limit greenhouse gas concentration in the atmosphere to a level which would avoid dangerous manmade interference with climatic systems. The UNFCC is the accepted international standard for worldwide cooperation in controlling anthropogenic GHG emissions. The UNFCCC requires every signatory country to produce an annual national inventory of GHG emissions for the previous year, divided into four general categories (energy; industrial processes; agriculture, deforestation and other land use; waste). So far, 90 countries have submitted plans to the UNFCCC proclaiming intentions of cutting emissions by 2020. This includes 48 developing countries [13].

Kenya is a signatory of both the UNFCCC and has ratified Kyoto Protocol, meaning it has an obligation to participate in international climate change events such as annual Conference of The Parties (COP) on Climate Change. In 2006 the UNFCCC held its 12th Conference of Parties (COP) in Kenya. The Nairobi framework is the most significant product and aims to assist developing countries, particularly those in Sub-Saharan Africa, in getting involved with the CDM [14].

Kyoto Protocol 1997 defines three variable approaches to help parties listed in Annex I meet targets set by COP 2 of UNFCCC:

a) Clean Development Mechanism by which a certain amount of Certified Emission Reduction (CERs) can be generated by investing in non-annex 1 parties.
b) Joint Implementation (JI) refers to the generation of credits for investments in emission reductions between Annex I countries.
c) National portion of emitters International Emission Trading (IET), lets a country sold to one that has failed to meet its target.

This study on the generation of renewable energy from wastewater can pass as a Clean Development Mechanism and be accorded premium as per the CDM National Clearing House (NCH). One of its objectives is to quantify the level of emission reduction that can be achieved by converting methane to energy rather than it being released freely into the atmosphere. This is because this project can be taken up by Annex 1 countries as a means to reduce their emission targets. Since CC is a global matter then both sides will have benefitted from such investments Kenya being able to minimize emissions as well as eradicate poverty by providing alternative cheap energy for cooking.

2.4 Research Gap

According to the Energy Regulation Commission, there are eight thousand plants producing biogas in Kenya. The plants utilize various raw materials-such as agricultural waste, slaughterhouse or municipal wastes etc. There is however a challenge in accounting for all biogas produced in Kenya because there is no verified concrete data making it difficult to assess biogas potential in Kenya [15].

This study aims at giving an estimation of biogas produced at Dandora Wastewater Treatment Plant in order to be able to estimate the energy equivalent of the same. This study can then be replicated in other treatment plants in Kenya with the overall aim of determining the carbon footprints of wastewater treatment plants in Kenya.

3. MATERIALS AND METHODS

3.1 The Study Area

This research was conducted at Dandora Wastewater Treatment Plant (DWWTP). DWWTP is located 30km to the East of Nairobi Central Business, at latitude $1^0 14^1$S and longitude 37^0 15^1E (Fig. 1). It is designed to treat about 120,000m^3 of sewage per day (80% of Nairobi's wastewater). The map below shows pictorial view of the treatment works site.

The arrangement of the ponds is shown in Fig.2.

3.2 Data Collection and Type

The study employed both primary and secondary data. Operational (secondary) data on the raw sewer in mg/l, COD and BOD levels was collected from DWWTP which has been documented between 2007 and 2013. These years were settled on since the data was more consistent than all the other years. Additional primary data was collected in 2013 to confirm the consistency of operational data obtained from DWWTP. This synthesized data was then analyzed in excel sheet to calculate the BOD loading and removal rates, total methane generated, thus energy equivalent and the emission reduction equivalent using the formulas given in the subsequent sub sections. The entire study was structured into tasks that were performed during the proposed study period as summarised below to achieve study objective;

Fig. 1. Map of DWWTP (Source: Meteorological Department)

Fig. 2. Layout of DWWTP (Source: Google Earth, 2013)

i) 3.2.1 Computation of biogas generated at the dandora treatment plant

Objective (i) was computed by following two steps as mentioned below;

Step 1: Estimation of BOD loadings and removals

$$\text{BOD Load} = \text{Design of the pond } (m^3/d) \times \text{BOD raw sewage } (mg/L)$$

$$\text{BOD Loading rate} = \text{BOD Loading } (g\backslash day) \div \text{effective volume of the pond } (m^3)$$

$$\text{BOD Removed} = \text{Actual BOD removal} \times \text{BOD Load}$$

(Formulas as per Mara,[16]).

Step 2: Computation of Biogas Generation

The emission of methane from wastewater treatment at DWWTP was calculated according to Mara [16,7] formulae.

The key variable in the methane estimation from domestic and commercial wastewater is the Biochemical oxygen demand (BOD) from wastewater anaerobically treated.

From data analysis, the annual, monthly and daily averages of the BOD and COD effluent from the anaerobic ponds was computed to give the annual monthly and daily averages of the BOD and COD removals.

Biogas Generated = 90% of BOD Removed [16]

ii) Computation of energy equivalent of biogas produced.

The second objective was completed after computation of energy equivalent of biogas produced by following the steps mentioned below;

Energy value of biogas generated (MJ/d) =

Biogas generated per pond (m^3/day) X Fuel value of biogas (MJ/m^3)

Mara [16]

iii) Computation of emission reduction equivalent of converting biogas to energy

IPCC Guidelines for National Greenhouse Gas Inventories, (2006) were used to calculate Greenhouse Gas Emissions from Wastewater treatment plants. In principle, the IPCC has defined remaining methane emission as the total quantity of methane emission less the quantity of methane prevented from getting into the atmosphere through recovery (IPCC,[17]).

Emission getting into the atmosphere ($tCO_{2\text{-}e}$).

= Total Generated Emissions ($tCO_{2\text{-}e}$) – Methane prevented from getting into the atmosphere ($tCO_{2\text{-}e}$).

(IPCC,[17])

In other words;

Emission getting into the atmosphere is the Net emission (NE), Total generated emission is the Gross emission (GE) and Methane prevented from getting into the atmosphere is the Recovered Methane, methane recovery (MR) or potential emission reductions (PER).

The computation is as follows:

Potential Emissions Reductions ($tCO_{2\text{-}e}$)

= Total Baseline Emissions ($tCO_{2\text{-}e}$) - Total Project Emissions ($tCO_{2\text{-}e}$).

(IPCC,[17])

3.3 Data Analysis and presentation

Data was analyzed by use of MS excel. The results were presented in tables, bar charts and pie charts together with a summarised explanation in relation to the literature.

Correlation analysis was used to test relationship between the quantitative variables. In this case biogas generated, energy equivalent and emission reduction estimates. Pearson correlation coefficient was then used to test the relationship between the two variables.

3.4 Research Design

Correlation was used to discover the relationship between biogas converted to energy and climate change abatement. Correlation research design was chosen since it helps in prediction of future occurrences.

4. RESULTS AND DISCUSSION

4.1 Daily Inflows and Outflows

From the analyzed data between 2007 and 2013, it was apparent that the average inflow at the plant was 83648 m3/day which is about 52% of the design capacity of 160,000m^3/day.

Table 1. Average flows at DWWTP

Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Average
2007/08	75422	87857	82113	75486	92791	85980	77239	78911	81952	104251	91040	89672	85226
2008/09	74547	78882	78659	78659	100455	78529	63091	76219	72072	70889	86916	87709	78886
2009/10	75382	62910	52303	59030	82627	81692	107164	79672	96303	125069	120738	96378	86522
2010/11	86375	87126	89420	79561	91020	95458	82444	79244	80783	82644	83213	81744	84919
2011/12	88291	93633	90687	108262	110790	94175	77036	74507	67109	83014	92145	79526	88265
2012/13	75944	74657	68336	76507	84710	88279							78072
													83648

4.2 BOD Loading

Between the years 2007 and 2013, the average BOD loading is estimated at 407 mg/l which represented 79% of the design capacity of 512mg/l.

Table 2. Average BOD Loading

Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Average
2007/08	280	480	218	216	282	247	240	270	301	279	232	304	**279**
2008/09	383	416	417	417	403	427	524	586	652	590	518	531	**489**
2009/10	655	784	907	781	650	609	369	540	499	315	331	257	**558**
2010/11	428	523	522	516	272	379	581	517	359	498	477	391	**455**
2011/12	373	387	364	338	287	221	299	442	384	276	163	231	**314**
2012/13	294	306	379	318	247	198							**290**
Average	402	483	468	438	357	347	403	471	439	392	344	343	**407**

4.3 Biogas Production and Energy Equivalent

The plant was found to be generating approximately 2736m^3/day of methane at the calculated flow of 83648m^3 daily.

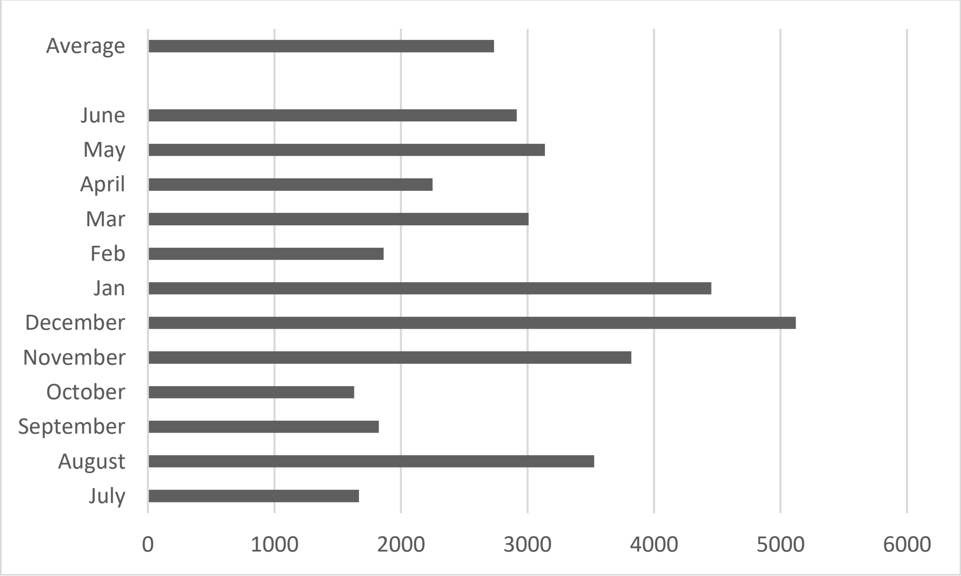

Fig. 3. Methane generated(m3/day)

Table 3. Daily methane generated for the period 2007-2013

Month	Methane generated(m^3/day)
July	1668
August	3527
September	1825
October	1631
November	3821
December	5121
Jan	4453
Feb	1862
Mar	3009
April	2251
May	3137
June	2916
Average	2736

4.4 Energy Equivalent of Biogas Produced

The amount of energy that can be produced from methane was computed as 68,398 MJ/day.

$$\text{Energy value of biogas generated (MJ/d)} = \text{Biogas generated per pond } (m^3/day) \times \text{Fuel value of biogas } (MJ/m^3)$$

$$\text{Energy value of biogas generated (MJ/d)} = 2736\ (m^3/day) \times 25\ (MJ/m^3)$$

$$\text{Energy value of biogas generated (MJ/d)} = 68398\ MJ/day$$

(IPCC, [17])and (Mara,[16])

Research from Burton and the Electric Power Research Institute (EPRI) in the US shows that anaerobic digestion with biogas utilization can produce about 525 KWh of electricity for every million gallons (3785m^3) of wastewater treated at the plant [18-21]. Using the same argument, DWWTP treating about 83643m^3 of domestic and industrial waste daily would generates roughly about 12MWh and at full capacity when treating 160,000m^3 daily would generate about 22.1MWh. These two figures relatively compare to my calculation of 18MWh.

To estimate the number of households that can be served by the amount of energy generated, the following were the assumptions made;

- Most households within Ruai are dependent on 3kg LPG gas for cooking
- Calorific Value of LPG gas cylinder is 46.1MJ/kg [22].
- Total no. of households in the project area is 22755 [23]

The total energy that can be generated at DWWTP is estimated at 68,398MJ/day, and considering Calorific Value of LPG of 46MJ/kg, this is equivalent to 495 cylinders daily which can serve about 2974 households daily.

Economic value of 3kg cylinders can be estimated by 495*800/= which is equivalent to saving Kshs. 396,000 daily.

Ashlynn et al [18] reiterates that Wastewater treatment plants with treatment capacities of less than 5 million gallons per day (18,900m^3) do not produce enough biogas to make electricity generation feasible or cost-effective [18]. Based on this, it can be argued that Dandora generating about 83,643m^3 per day can generate enough biogas to make energy or electricity generation feasible and cost effective.

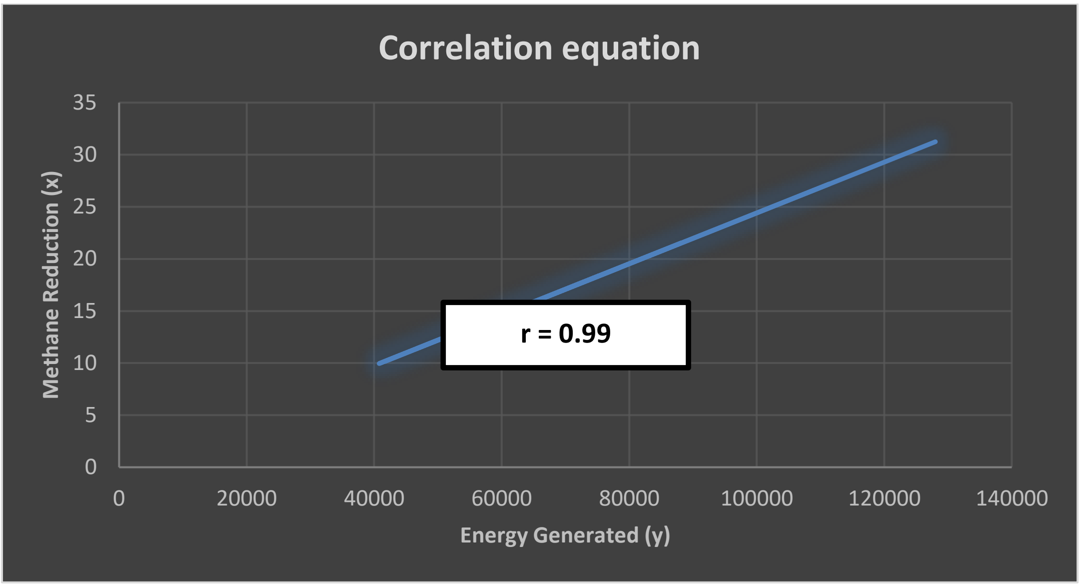

Fig. 4. Correlation between biogas converted to energy and emission reduction

Table 4. Correlation coefficient parameters

Energy Generated (y)	Methane Reduction	XY	X^2	Y^2
111325	27	3024643	12393255625	738
46544	11	528703	2166320664	129
75219	18	1380832	5657860352	337
56263	14	772550	3165468906	189
78425	19	1501059	6150480625	366
72894	18	1296789	5313498789	316
41688	10	424131	1737847656	104
88163	22	1896953	7772626406	463
45631	11	508175	2082210977	124
40781	10	405891	1663110352	99
95513	23	2226430	9122637656	543
128019	31	3999778	16388800352	976
880463	215	17965935	73614118359	4385

Based on the above the r = 0.99

4.5 Computation of Emission Reduction of Converting Biogas to Energy

For this calculation, the electricity generation for the baseline scenario is supplied by generators using Heavy Fuel Oil (HFO), with an Emissions Factor (EF) of 0.896 t CO_2/MWh[1]. For this analysis, the biogas capture and combustion at the DESTP as calculated earlier generates about 18MWh per day, thereby displacing 18MWh per day of HFO-generated electricity each year. The baseline emissions are therefore approximated as:

Total Baseline Emissions (tCO_{2-e}) =Electricity Generation x EF

= 18 MWh x 0.896 tCO_{2-e}/MWh
= 16.1280 tCO_{2-e} per day

Total Project Emissions (tCO_{2-e}) = Electricity Generation x EF

18 x 0.0174 tCO_{2-e}/MWh
= 0.3132 tCO_{2-e} per day

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[1] *Source: International Energy Agency, 'CO₂ Emissions from Fuel Combustion, 2012 edition.*

The GHG emission reductions attributed to this Project therefore the difference between the baseline and project emissions:

Potential Emissions Reductions ($tCO_{2\text{-}e}$)

= Total Baseline Emissions ($tCO_{2\text{-}e}$) - Total Project Emissions ($tCO_{2\text{-}e}$)

= 16.1280 $tCO_{2\text{-}e}$ per day - 0.3132 $tCO_{2\text{-}e}$ per day

= approx. 16 $tCO_{2\text{-}e}$ per day

According to Greenhouse Gas Equivalencies calculator by EPA, 2023[2]; the figure 16 $tCO_{2\text{-}e}$ per day is equivalent to carbon sequestered by 240 tree seedlings grown for 10 years or equivalent to CO_2 emissions from 1633 gallons of gasoline consumed this emphasizes on the significance of this amount of emission reduction in combating climate change [24,25]

4.6 Pearson Correlation Coefficient

The following formula was used to calculate the relationship between the two variables that is energy recovered and emission reductions. Ref.

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2]\,[n\Sigma y^2 - (\Sigma y)^2]}}$$

The study's results on the correlation analysis between energy generated and emission reduction equivalent, showed a perfect positive correlation with a high value of $r = 0.99$ as shown Fig. 4.

This confirms that energy recovery from Dandora Wastewater treatment plant is significant in mitigating climate change and thus rejects my null hypothesis that Conversion of Biogas to energy doesn’t have significant effect on emission reduction.

5. CONCLUSION

The study concludes that recovery of energy from waste water treatment plant can help in combating climate change. This confirms that energy recovery from Dandora Wastewater treatment plant is significant in mitigating climate change.

In their last submission of Nationally Determined Contributions of 2020, Kenya is undertaking an ambitious mitigation contribution towards meeting the Paris Agreement of 2015 by abating her GHG emissions by 32% by 2030 relative to the Business As Usual (BAU) scenario of 143Mt CO2eq. As per our estimations, this project will help reduce GHGs emissions by at least 16 $tCO_{2\text{-}e}$ per day. These findings give an impetus to the government of Kenya and other relevant stakeholders to develop green energy from methane generated at the treatment plant thereby reducing GHGs emitted to the atmosphere in line with Kenya's NDC commitment to abating the climate change menace.

6. RECOMMENDATION

- This project can be one among many projects in the waste sector that Kenya can implement to meet its National Determined Contributions (NDC) as per Paris Agreement of 2015 that is abate climate change by 32% against Business As Usual of 143M $tCO_{2\text{-}e}$ by 2030.
- Harnessing methane should be encouraged as an alternative green energy for use by the local community around the treatment plant.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

APPENDIX 1. Data Analysis

MONTHLY AVERAGES FOR THE YEAR 2007/2008

Measurements	**Unit**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**Year Averages**
Inflow	m^3/d	75422	87857	82112.57	75486	92791	85980	77239	78911	81952	104251	91040	89672	85226
BOD	mg/l	280	480	218	261	282	247	240	270	301	279	232	304	283
COD	mg/l	568	650	710	648	777	722	595	745	706	585	648	691	671
TSS	mg/l	358	410	463	378	441	491	396	426	386	379	431	422	415
TS	mg/l	358	951	985	846	957	972	768	948	978	996	964	1048	898
TDS	mg/l	684	538	531	473	507	464	374	547	597	616	637	665	553
Chlorides	mg/l	656	57	69	70	66	47	55	50	68	64	50	61	109
NO_2	mg/l	4		2.19	1.04	0.17				22.9	5.7	12.15	9.00	7
NO_3	mg/l	38		31.00	6.14	0.98						7.92	8.57	15.42
PO_4	mg/l	14.78		25.16	2.12								24.41	16.62
PH	Ph	8.10	7.94	7.69	7.8	7.83	7.18	7.6	8.15	7.39	7.35	7.42	7.30	7.65
Temperature	^{0}C		20.70	20.90	21.3	21.35	19.66	21.6	21.89	22.39	21.97	21.95	21.56	21.38
D.O	mg/l		2.27	5.82	1.01	0.34	1.00	7.25	4.91	0.35	0.14	0.08	0.30	2.13

MONTHLY AVERAGES FOR THE YEAR 2008/2009

Measurements	**Unit**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**Year Averages**
Inflow	m^3/d	74547	78882	78659	78659	100455	78529	63091	76219	72072	70889	86916	87709	78886
BOD	mg/l	383	416	417	417	403	427	524	586	652	590	518	531	489
COD	mg/l	764	1062	1134	1134	1067	1374	1541	1561	1406	1145	1052	1395	1219
TSS	mg/l	459	407	517	517	630	643	945	808	853	662	708	608	647
TS	mg/l	1181	1158	1350	1350	1347	1481	1864	1755	1613	1404	1475	1402	1448
TDS	mg/l	738	720	812	812	715	800	884	876	779	816	777	770	792
Chlorides	mg/l	72	75	80	80	82	85	94	87	97	96	94	103	87
NO_2	mg/l	9.1	6.1	16.9	16.9	1.9			1.1		Trace	0.000	n/d	7.4
NO_3	mg/l	22.76									2.5	5.000	13.750	11.00
PO_4	mg/l	25.46	30.76	14.68	14.68	24.3								21.97
PH	Ph	7.2	7.2	7.6	7.58	7.5	7.43	7.3	7.2	7.3963	7.5	7.9	7.9925	7.5
Temperature	^{0}C	20.1	19.9	21.8	21.8	23.6	23.683	22.9	23.3	23.946	24.2	23.3	22.094	22.5
D.O	mg/l	0.4	18.32	0.81	0.81	1.65	2.104	1.9	1.65	2.435	1.5	4.15	2.302	3.2

MONTHLY AVERAGES FOR THE YEAR 2010/2011

Measurements	Unit	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Year Averages
Inflow	m^3/d	88375	87126	89420	79561	91020	95458	82444	79244	80783	92644	83213	81744	84910
BOD	mg/l	428	523	522	516	272	379	581	517	358	498	477	391	455
COD	mg/l	853	1098	1512	1187	858	1088	1394	1513	1108	1179	858	883	1127
TSS	mg/l	115	568	605	546	542	511	642	678	421	574	634	680	682
TS	mg/l	1071	1201	1296	1303	1202	1197	1389	1409	1141	1304	1437	1317	1266
TDS	mg/l	817	690	643	656	627	646	700	745	687	733	780	720	688
Chlorides	mg/l	0.5	86	94	96	99	91	86	106	107	91	102	99	95
NO_2	mg/l	0.86	2.14	5.98	1.51	1.34	1.17	0.12	0.25	0.33	1.53	0.27	0.28	1.31
NO_3	mg/l		21.46	6.35	13.54	15.73	8.59		3.31	5.00	3.50	2.00	2.75	8.22
PO_4	mg/l	8.14	31.39		25.22	23.40	21.10	11.80						
PH	Ph	7.43	7.71	6.9	7.28	7.12	7.18	7.05	7.20	7.24	6.97	8.92	7.07	7.13
Temperature	^0C	17.1	19.4	18.69	20.9	20.9	20.7	22.5	22.8	23.0	23.30	22.31	21.36	26.95
D.O	mg/l	-						0.74	1.17	1.58	2.39	5.10	1.87	2.14

MONTHLY AVERAGES FOR THE YEAR 2011/2012

Measurements	Unit	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Year Averages
Inflow	m^3/d	88291	93633	90687	108262	110790	94175	77036	74507	67109	83014	92145	79526	88265
BOD	mg/l	373	387	364	338	287	221	299	442	384	276	163	231	314
COD	mg/l	898	972	901	930	729	769	650	951	795	746	402	574	769
TSS	mg/l	515	502	483	542	549	438	357	479	355	393	365	329	442
TS	mg/l	1165	1271	1203	1210	1178	1054	941	1251	1057	1040	896	914	1098
TDS	mg/l	626	686	644	613	572	550	524	720	703	645	520	578	615
Chlorides	mg/l	91	101	102	101	91	91	99	111	81	77	64	102	93
PH	Ph	7.14	7.56	7.22	7.15	7.15	7.17	7.07	7.22	7.14	7.45	7.52	7.46	7.27
D.O	mg/l	3	3	3	4	2	3	3	3	3				2.92

MONTHLY AVERAGES FOR THE YEAR 2012/2013

Measurements	Unit	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Year Averages
Inflow	m^3/d	75944	74657	68336	76507	84710	88279							78072
BOD	mg/l	294	306	379	318	247	198							290
COD	mg/l	613	670	813	679	555	479							635
TSS	mg/l	346	308	370	346	323	289							330
TS	mg/l	999	933	1304	954	896	795							980
TDS	mg/l	634	605	658	612	537	466							585
Chlorides	mg/l	86	83	93	74	71	61							78
NO_2	mg/l	0.042	1.125			0.140								0.436
NO_3	mg/l	2.735	2.500	101.167	78.017									46.105
PH	Ph	7.6	7.5	7.3	7.1	7.3	7.4							7.36
Temperature	^{0}C	19.5	19.5	20.2	21.4	21.9	21.5							20.66

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