GREENHOUSE GASES (GHG) INVENTORY STUDY FOR AN INDUSTRIAL WASTEWATER TREATMENT PLANT

DOLGEN D.[1], **KULAH S.**[2] **and ALPASLAN M.N.**[1]

[1] Dokuz Eylul University, Faculty of Engineering, Department of Environmental Engineering, Tinaztepe Campus, Buca 35160, Izmir, Turkey, [2] ÇevreTEK, Company of Environmental Treatment Technologies, Keremoğlu Business Center 5-D Yenisehir, Izmir, TURKEY
E-mail: deniz.dolgen@deu.edu.tr

ABSTRACT

Wastewater treatment plants (WWTPs) is considered as one of the main emission source of the greenhouse gases (GHG). GHG emissions inventory studies are an effective tool to quantify the amount of greenhouse gases emitted into the atmosphere by activities in a defined area and at a specific time period. The aim of the presented study is to indicate the sources and quantities of GHG emissions from an industrial wastewater treatment plant (WWTP). The GHG inventory study of the examined WWTP was accomplished by using the GHG protocol directives and guidelines. In this framework, different parts of the treatment plant and auxiliary facilities which yields GHG under various scopes were examined during the operation phase. Indirect GHG emissions (scope 2) based on the electricity consumption from mechanic equipment at WWTP was calculated as 897.5 tons CO2/year. The GHGs emissions due to electricity consumption in the operational building from air conditioner, computer and WWTP lighting was also considered in indirect emissions and estimated as 5.9 tons CO2/year. Moreover, other indirect emissions (e.g. transportation of chemicals and employees) to company were estimated in “Scope 3”. The other indirect emissions were calculated as 22 tons per year considering the vehicle type, distance, and other factors. Finally, total emissions of the WWTP were calculated as about 925 tons CO2 per year.

Keywords: carbon footprint, GHG (greenhouse gases), GHG protocol, wastewater treatment plant (WWTP)

1. Introduction

Wastewater treatment plants (WWTP) have been accepted as an emission source of the greenhouse gases (GHGs). The types of GHGs emissions generated from a typical wastewater treatment process schemes are carbon dioxide (CO_2), methane (CH_4), and nitrogen oxide (N_2O) emissions. The Greenhouse Gas Protocol (GHG Protocol) is one of the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. The GHG Protocol categorizes the emissions into three broad scopes. Scope 1 includes the direct greenhouse gas emissions occurring from sources that are owned or controlled by the company. Scope 2 comprises of indirect GHG emissions from consumption of purchased electricity, heat or steam. Scope 3 includes other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc. Both direct and indirect greenhouse gas emissions of the facility are considered to quantify the total gross GHG emissions. Accepted methods are employed to estimate CO_2 emissions from direct stationary combustion and indirect sources. Emissions occur inside the WWTP due to biological processes used for the removal of contaminants is either not reported or is kept separate from other GHG emissions.

The most essential issue in controlling GHG is to quantify them. The quantification reveals the targets and the priorities, thus guide on setting the GHG reduction goals. Steps followed for preparing a GHG inventory may be listed as follows:

i) Setting organizational and operational boundaries
ii) Identifying emissions sources
iii) Tracking emission sources over time
iv) Calculating GHG emissions

In this framework, an inventory study to quantify the greenhouse gas emissions produced by an industrial wastewater treatment plant is carried out by following the steps indicated above. GHG inventory of the WWTP is completed by using the GHG protocol to define the types of emissions produced from treatment facilities and from which parts of the treatment plant. With the results of the study, main contributors to the GHG emissions of examined WWTP are expressed and improvements to reduce the emissions are evaluated.

2. Material and methods

In this study, GHG inventory is carried out in an industrial WWTP processing the meat and meat products in Turkey. Process and domestic wastewater has been treated in the plant with a capacity of 6,000 m3/day. The examined WWTP consists of pre-treatment (screening and equalization), chemical treatment (neutralization, floatation, coagulation, flocculation), biological treatment (conventional aerobic activated sludge process), and sludge treatment units (thickening and dewatering). In order to quantify the emissions, organizational and operational boundaries were established as first, and then emission sources were identified. The GHG emissions were calculated using GHG Protocol methodology. The plant's GHG was considered mainly of scope 2 and scope 3 emissions related to the operation of the treatment process and associated equipment, and transportation as well. The electricity consumption of mechanic equipment was used to determine the indirect emissions of the WWTP. Emissions from transport and distribution of chemicals, transportation of employees, transportation of wastes and coal (lignite) to company were also estimated in Scope 3, as other indirect emissions.

3. GHG calculations

The GHG emissions were calculated using GHG Protocol methodology and calculation program. Purchased Electricity Tool was used to calculate GHG emissions of Scope 2. Data required for calculations were global warming potential, country, region, percentage of electricity used by the facility, and consumption data. Electricity consumption of the WWTP was due to equipment in WWTP and electric appliances in the operating buildings. All mechanic equipment used in the WWTP and electric appliances are presented separately in Table 1 and 2 respectively.

Transport Tool was used in order to calculate the other indirect GHG emissions, i.e. scope 3. Transport and distribution are the focal point of other indirect GHG emissions, thus data regarding to transportation of stuff, chemicals, etc. was considered to determine the emissions. In this framework, purpose of vehicles, region, transport type, e.g. road, rail, water or aircraft, activity data, e.g. vehicle distance (e.g. road transport), fuel amounts and type was required for calculations. Travelling distances used for staff and chemicals, vehicle types used in transportation is presented in Table 3 and 4.

4. Results

In the study, energy consumptions of mechanic equipment were calculated using data given in Table 1. GHG emissions were found as 897.5 tons CO_2/year. Besides, energy consumption in the operation building and site lighting were determined as indirect GHG emissions. The GHGs emissions due to electricity consumption in operator building (air conditioner, computer and WWTP lighting) were about 5.9 tons CO2/year (see Table 5).

Emissions from transport and distribution of chemicals ($FeCl_3$, lime, anionic and cationic polymers are bought from a company located 50 km away), transportation of employees, transportation of wastes and transportation of coal (lignite) to company were calculated in Scope 3, as other indirect emissions. In this context, transport for chemicals and also employees were taken into consideration. As can be seen from Table 6, CO_2 emissions were calculated as 22 tons per year considering the vehicle type, distance, and other factors.

Therefore, total GHG emissions generated at meat processing WWTP were calculated as about 925 tons of CO2e. As can be seen from the Table 7, electrical consumption was one of the significant emission sources of the examined plant. Among the mechanic equipment, blower and pumps were highest energy consumed equipment because %88 of energy consumption has been used. Therefore, blowers and pumps need special attention to reduce electric consumption. Since inventers regulate engine speed and prevent excessive operations, using of inventers is supposed as an effective tool to reduce energy consumption. Inverters can be used either synchronize operating with oxygen meters in aeration basins or with manual adjustment mode.

5. Conclusions

The study is used for estimating GHG emissions from an industrial WWTP. Under the examined configuration, the plant's GHG was comprised mainly of indirect emissions, i.e. scope 2 and scope 3 emissions. Consumption of the electricity was one of the significant emission sources of the plant. Among the mechanic equipment, blower and pumps were the highest energy consumed equipment because %88 of energy consumption has been used. Therefore, blowers require special attention to reduce electric consumption and GHG emissions. Since inventers regulate engine speed and prevent excessive operations, use of inverters is recommended to reduce the energy consumption. Besides, tree planting method is also considered as cheapest and easiest method for carbon offsetting. The company can be neutral by planting 5173 tree in each year.

Table 1: Energy consumption of the equipment in WWTP

Equipment	No	Unit Power (kWh)	Total Power (kWh)	Daily Working Time (h)	Daily Energy Consumption (kWh)
Screening System	1	0,37	0,37	24	8,88
Jet Aerator	1	7,5	7,5	5	37,5
Coagulation Basin Mixer	1	1,5	1,5	24	36
Flocculation Basin Mixer	1	1,1	1,1	24	26,4
Flotation Scraper	1	1,1	1,1	24	26,4
Compressor	1	7,5	7,5	24	180
Circulation Pump	1	22	22	24	528
Oil Pump	1	0,75	0,75	2	1,5
Domestic W.Water Pump	1	2	2	2	4
$FeCl_3$ Dosage Pump	1	0,37	0,37	5	1,85
A.P.E. Dosage Pump	1	0,37	0,37	5	1,85
C.P.E. Dosage Pump	1	0,37	0,37	5	1,85
Chemical Prep. Tanks Mixer	2	0,6	1,2	2	2,4
Sludge Pump/a	1	1,5	1,5	2	3
Equalization Basin Pump	2	7,5	15	24	360
Sludge Pump/b	2	2,2	4,4	2	8,8
Blower	5	75	375	10	3750
Neutralization Basin Mixer	2	1,5	3	24	72
Lime Dosage Pump	2	0,37	0,74	5	3,7
Sedimentation Basin Scraper	2	0,75	1,5	24	36
Lime Prep. Tank Mixer	2	0,75	1,5	2	3
Sludge Thickening Basin Mixer	1	0,18	0,18	2	0,36
Belt press	1	1,1	1,1	2	2,2
Oxygen Meter	2	0,22	0,44	24	10.56
pH Meter	3	0,22	0,66	24	15.84
Sampling Unit	1	0,22	0,22	1	0,22
				Total Consumption	**5122 kWh/day**
					1870MWh/year

Table 2: Energy consumption of electrical appliances

Electric Appliance	No	Power (Piece) kWh	Working Period	Energy Consumption kWh /year
Computer	1	0,35	8h/d x 261d/y	730,8
Air Conditioner	1	1,1	8h/d x 261d/y	2296,8
Halogen Lamp	2	1	12 h/d x 365d/y	8760
Fluorescent	1	0,04	2 h/d x 261d/y	20,88
Fluorescent	3	0,04	12 h/d x 365d/y	525,6
			Total	**12334 kWh/year**
				12.3 MWh/year

Table 3: Vehicle used for chemical purchase

Chemicals	Period	Vehicle Type	Distance	Total Distance
$FeCl_3$	Once a week	Tanker	50 km/week	2600 km/year
Lime	Once a week	Truck	50 km/week	2600 km/year
Anionic Polymers	Once a month	Truck	50 km/month	600 km/year
Cationic Polymers	Once a month	Truck	50 km/month	600 km/year
			Total	**6400 km/year**

Table 4: Vehicle used in employee transportation

Personnel	Town	Distance from work	Distance	
			km/week	**km/year**
Engineer	Bornova	29 km	174	9048
Employee	Kemalpaşa	5 km	30	1560
Employee	Turgutlu	30 km	180	9360
			Total	**19968 km/year**

Table 5: Indirect GHGs emissions from electricity consumption

Facility Description	Consumption (MWh)	Emission Factor (kg GHG/kWh)		GHG Emissions (tons)	
		CO_2	CO_2e	CO_2	CO_2e
Equipment in WWTP	1,870	0,479929	N/A	897.5	897.5
Operating Building	12,334	0,479929	N/A	5.9	5.9

Table 6: The other indirect GHGs emissions due to transportation

Source	Vehicle Type	Distance (km)	GHG Emissions (tons)	
			CO_2 (tons)	CO_2e (tons)
Chemical transport	Heavy Duty Vehicle - 1960-present	6,400	4.6	4.6
Employee service	Light Goods Vehicle - Year 1983-1995	19,968	7.8	7.8
Coal transport	Heavy Duty Vehicle - Year 1960-present	13,550	9.7	9.7

Table 7: GHG emissions from WWTP

GHG Emissions			
GHG Source Type	**GHG Source**	**CO_2e (tons)**	**Percent (%)**
Indirect (Scope 2)	Blowers	657.1	71
	Pumps	160.2	17.31
	Scraper and Mixers	35.5	3.84
	Compressor	31.5	3.4
	Jet Aerator	6.6	0.71
	Measuring Devices	4.7	0.51
	Screening	1.6	0.17
	Belt press	0.4	0.04
	Operation Building	5.9	0.64
Other indirect (Scope 3)	Transportation of chemicals, wastes, and employees	22.0	2.37
Total		**925.5**	**100**

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