CH_4, CO_2 AND SO_2 EMISSIONS FROM THE HULENE DUMP, MUNICIPALITY OF MAPUTO

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ABSTRACT

The objective of this work is to evaluate the amount of CH_4, CO_2 and SO_2 that is currently emitted by the Hulene dump into the atmosphere. The work consisted in measuring these three gases using an S360 multigasometer that simultaneously measures eight gases. Measurements were made in April, May, June, July, August and September, which are considered the dry season in Maputo city. Measurements were made at 18 points of gas release pipes installed by the Municipality of Maputo. Point P10, presents the highest value of 2.56 and 2.59 (% vol of CH_4), respectively in the months of April and May. Point P14 had the highest value of 2.95 (% vol of CH_4) in April and 2.28 (% vol of CH_4) in May. Point P15 presented values of 2.78 and 2.72 (% vol of CH_4), respectively in the months of August and September. Points P10, P14 and P15 showed higher values of CH_4 in April, May, August and September. Points P9 to P13 showed marked variations of CO_2 in the months of July, August and September. Point P10 presented the highest value of 2.56 and 2.59 (ppm of CO_2), respectively in the months of April and May. Point P14 showed the highest value of 2.95 (ppm CO_2) in April and 2.28 (ppm CO_2) in May. Point P15 presented the highest value of 5,000 ppm of CO_2 in August and September. In April, points P1 to P6 showed values above 100 ppm of SO_2 and dropped drastically from point P7 to 3 ppm of SO_2. In April, P6 reached 137 ppm of SO_2. In August and September, the values gradually increased, reaching 178 ppm of SO_2 at point P18.

Keywords: biogas, emission, greenhouse effect

1 INTRODUCTION

The Hulene dump is a place where Maputo city's MSW has been deposited in the open for 30 years. The Hulene dump underwent improvement works to increase its solid waste receival capacity, increasing from 17 to 23 ha, after the tragedy that killed nineteen people, caused by the swelling of gases produced by the anaerobic digestion of the organic fraction of urban solid waste deposited. When the waste is deposited, the biodegradable fractions decompose through a complex series of microbial and chemical reactions, in addition to physical changes, with the result being the production of biogas [1]. Biogas basically consists of methane (CH_4), carbon dioxide (CO_2) and other gases in very low concentrations, such as several non-methane volatile organic compounds, which can be toxic [2]. In the sanitary landfill, the biodegradation of urban solid waste occurs through physical, chemical and biological processes, producing leaching water and gases. These processes occur over time and in aerobic, anaerobic non-methanogenic and methanogenic phases. CH_4 and CO_2 are the main gases inducing the increase in the greenhouse effect on the planet [3]. According to [4], landfills emit 18% of CH_4 and it is estimated that 35 to 69 tons of CH_4 are emitted annually into the atmosphere worldwide. In 2020, the Hulene dump received a total of 577,848.90 tons of urban solid waste, according to data provided by the Municipality of Maputo [5]. The Municipal Solid Waste Management Regulation (MSWMR) of Maputo City defines MSW as originating from domestic and commercial activities in urban settlements [6]. Methane (CH_4)

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and carbon dioxide (CO_2) reach the atmosphere during the deposition of waste, through percolation processes in the cover layers and through gas release pipes, the latter represents the places where biogases were measured. According to [7], [8], the production of gases in landfills starts from the first three months of solid waste compaction and extends until approximately 15–20 years after the deactivation of the area.

2 MATERIALS AND METHODOLOGY

To carry out this research, an S360 multigasimeter was used (Fig. 1), capable of measuring eight biogases by suction simultaneously, namely CH_4, CO_2, CO, NO_2, SO_2, O_2, H_2S and H_2. The S360 series equipment is a portable multi-gas detection instrument with high sensitivity for industrial use. It can detect different gases according to different types of sensors, with rich functions, simple operation, easy to carry and good shock resistance. This product uses high resolution touch LCD technology, the screen is more intuitive, clear, and more convenient to operate. The multigasimeter is equipped with a high temperature detector, suitable for high temperature gas occasions. In this work, only three gases are treated. The gases were measured at 18 points previously defined and installed by the Municipality of Maputo, through a project in partnership with the Japanese government, as part of the requalification of the dump. The 18 points are distributed in 3 lines of 6 points each and spaced 20 m apart on the line and 5 m high, with gabion protection at the end of each bench (Fig. 2). The choice of measurement points considered the existing points where pipes for continuous release of biogas were installed, which passes through a network of pipes installed at the bottom of the dump, allowing the circulation of biogas inside the dump, and releasing it through the pipes (Fig. 3). Measurements were taken in the last week of each month during a 6-month period of the dry season, starting in April and ending in September 2021.

Figure 1: Multigasimeter S360.

Figure 2: Bench with gas release pipes.

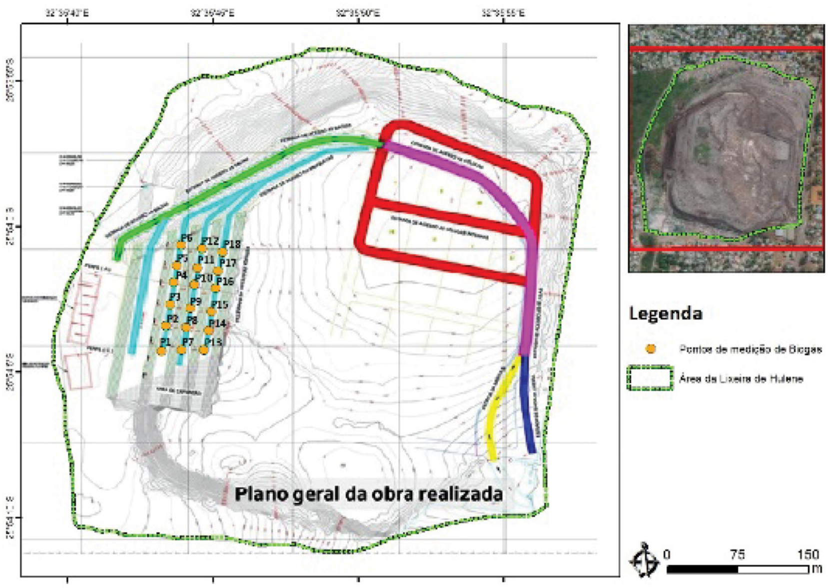

Figure 3: Biogas measurements points (adapted from [9]).

3 FRAMEWORK OF THE STUDY AREA

The city of Maputo is in Mozambique on the west bank of Maputo Bay in the extreme south of the country, close to the South African border and Swaziland's border. The limits of the municipality of Maputo are between latitudes 25º49′09″S and 26º05′23″S and longitudes 33°00′00″E (on the island of Inhaca) and 32°26′15″E, at an average altitude of 47 m. The municipality has an area of about 346.77 km^2 and a population density of 35 hab/km^2. About 60% of the population of this municipality works in the informal sector, with the remaining 40% of the population in the formal sector, divided into the areas of fishing, agriculture, manufacturing, tourism and services. Throughout the year, the temperature varies from 16°C to 29°C and is rarely below 14°C, often exceeding 40°C in the rainy season. The Hulene dump is located about 7 km from downtown Maputo, in the KaMavota district, covering an area of 23 ha (Figs. 4 and 5). The municipality of Maputo is made up of seven municipal districts, namely: KaMavota, KaMaxaquene, KaMpfumo, KaMubukwane, KaNlhamakulo, KaTembe and KaNyaka. Waste produced in KaTembe and KaNyaka districts is not deposited into the Hulene dump. The KaTembe district is located on the southernmost bank of Maputo Bay while the KaNyaka district is an island, which means that its waste does not reach the Hulene Municipal dump. The dump has been exploited since 1972, reaching the end of its useful life in 2016 and extended in 2018 for another 10 years due to compaction work. The dump has an extension of 17 ha and a maximum height of accumulated waste of about 30 m. Commerce is characterized by two types of markets: the formal, which comprises the retail and wholesale trade network, and the informal, comprising fixed and mobile resellers scattered throughout the city streets and in the formal and informal markets. In the green belt of Infulene, a variety of vegetables are produced. In many suburban neighbourhoods, poultry, rabbits and swine are raised. In urban neighbourhoods, the sanitation of the environment is served by a public drainage system of domestic wastewater and conventional rainwater built in the colonial era and in the older and emerging peri-urban neighbourhoods, it consists essentially of septic

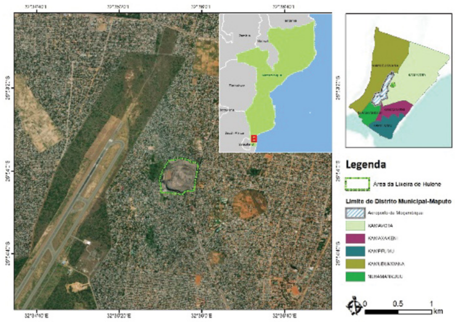

Figure 4: Hulene municipal dump location.

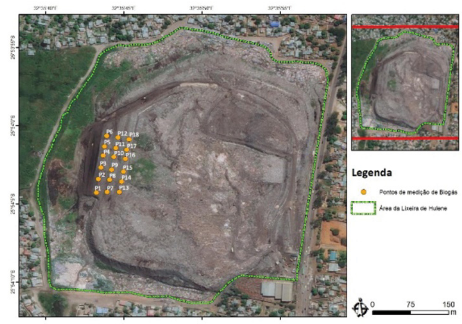

Figure 5: Hulene municipal dump.

tanks, generally without connection to the public system of drainage. In terms of environmental legislation, the municipality has legal and regulatory instruments for GRSU in which each of them complements each other in the absence of a more adequate policy, namely:

- Decree No. 94/2014, of 31 December: Regulation on Urban Waste Management [6]; and
- Resolution No. 86/AM/2008, of 22 May, Cleaning Posture of Urban Solid Waste in the Municipality of Maputo [10].

4 PHYSICAL COMPOSITION OF MSW AND MANAGEMENT STRUCTURE

Pursuant to article 14 of the Regulation on GRSU of the municipality of Maputo, waste must be segregated according to the following categories: paper/cardboard, organic matter, rubble, plastic, glass, metal, textiles, rubber, bulky household waste and special waste. The annual deposition of municipal waste in the Hulene dump increased from 127,385 tons in 2007 to 365,000 tons in 2017 [5]. In that period, the collection capacity increased from 39.93% to 84.10%. Peri-urban neighbourhoods, with about 75% of the population, are responsible for the average production of 73% of organic matter against 64% generated in urban neighbourhoods [5]. The MSW produced in the city of Maputo are the following: paper/cardboard, textiles, glass, metals, plastic, organic matter and others. Bulky household waste, which includes construction waste, is used in foundation landfills for new construction works. The Hulene dump does not receive this type of waste. Waste pickers essentially collect waste such as cardboard and cover boxes, plastics, pet bottles, glass bottles and metals and sell them to companies that export them to South Africa. The Municipal Council of Maputo City is responsible for cleaning municipals streets and collecting waste produced in the city. According to [5], the per capita rate of MSW generation in the city of Maputo is 1 kg/inhabitant/day in urban areas and 0.56 kg/inhabitant/day in suburban areas. Gani et al. [5] also states that the average capitation rate in the city is 1.06 kg/inhabitant/day. The Municipality of Maputo engaged, in a public-private partnership (PPP), two companies for the collection of MSW in the city of Maputo, namely Ecolife, which collects waste in the urban area and Envioroserv, which collects waste in the suburban area, then deposits them in the Hulene dump [11]. Micro-enterprises that collect waste at specific locations and that can collect, whenever requested for this purpose, upon payment of amounts to be agreed between the parties, have been licensed, but these companies do not deposit the waste in the Hulene dump, these being the wastes that are selected for recycling.

5 RESULTS AND DISCUSSION

Table 1 shows the results of measurements of meteorological conditions, temperature and humidity, for the days in which the biogas measurements were made in each of the indicated months. It was observed that the lo west temperature value was measured in May and August and the highest temperature was measured in April. In turn, the lowest value of humidity was registered in the month of June and the highest value was registered in the month of August.

The graph in Fig. 6, illustrates the methane measurements taken at the 18 sampling points. Point P10 has the highest value of 2.56 and 2.59 (% vol of CH_4), respectively in April and May, compared to the remaining points in other months. Point 14 has the highest value of 2.95 (% vol of CH_4) in April and 2.28 (% vol of CH_4) in May. Point P15 presents values of 2.78 2 2.72 (% vol of CH_4), respectively in the months of August and September. Points P10, P14 and P15 present higher values than the other points in the months of April, May, August and September. The month of April presents itself simultaneously with higher values of temperature and humidity.

The graph in Fig. 7 illustrates the CO_2 measurements taken at the 18 sampling points. Points P9, P10, P11 have higher values, ranging from 3,000 to 5,000 ppm of CO_2, respectively in the months of June, August and September. Point P13 has the highest value in July, reaching 3,000 ppm. Point P15 has the highest value of 5,000 ppm of CO_2 in the months of August and September. The month of August has the highest humidity.

Table 1: Characteristics of Bakun HEP.

Month	Temperature (°C)	Humidity (%)
April	25	77
May	20	66
June	22	45
July	21	47
August	20	85
September	23	52

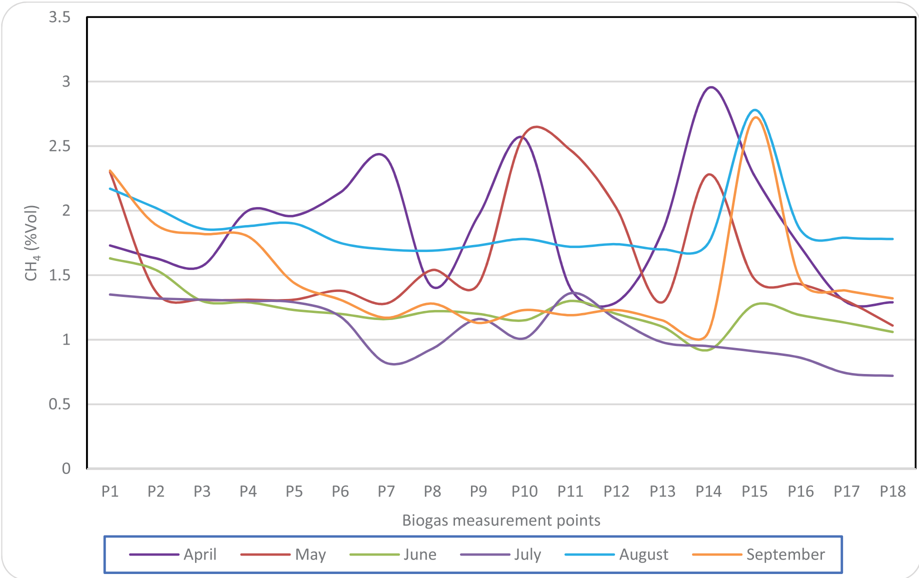

Figure 6: Results of CH_4 measurements.

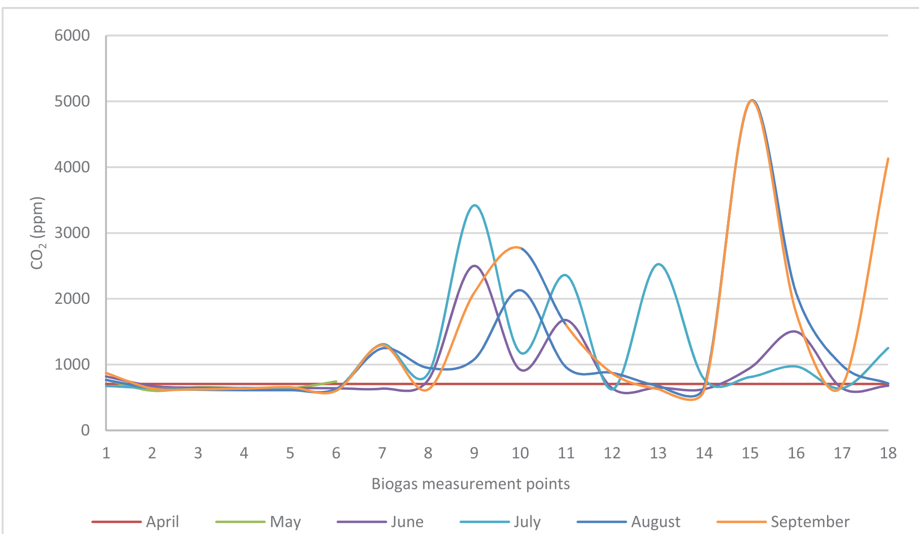

Figure 7: Results of CO_2 measurements

The graph in Fig. 8 illustrates SO_2 measurements taken at the 18 sampling points. In the month of April, points P1 to P6 showed values above 100 ppm of SO_2, which dropped drastically from point P7 to 3 ppm of SO_2. In the same month of April, P6 reached 137 ppm of SO_2. In the months of August and September, the values gradually increased, reaching 178 ppm of SO_2 in P18. There is no data registered in May.

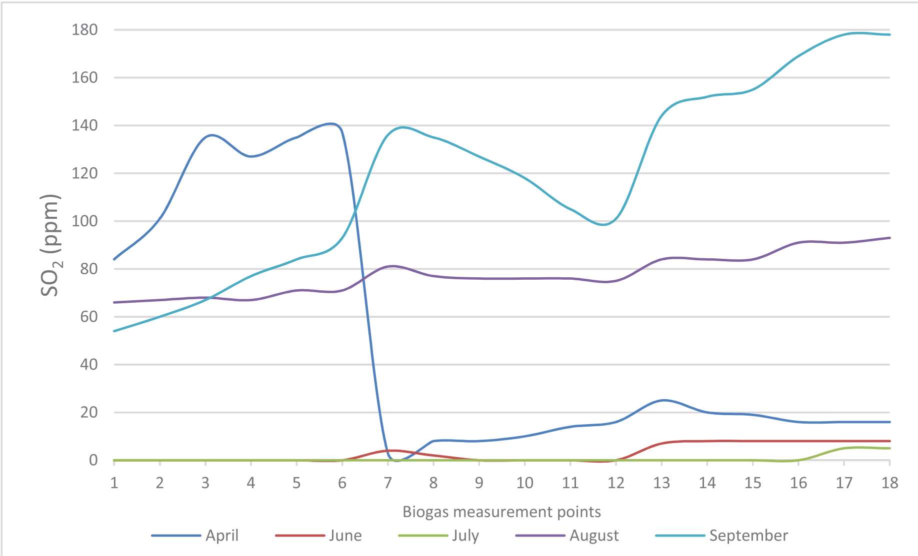

Figure 8: Results of SO_2 measurements.

6 CONCLUSIONS

According to the results obtained, it is concluded that the points P7, P10 and P14 presented higher values of methane emission in the month of April compared to the other months studied in this work. These points, according to the location of the biogas metering points in the Hulene dump, are on the highest quota lines where the waste deposited is relatively more recent. In July, points P7 and P8 had the lowest methane emissions values. The months of April, May, August and September had the highest methane emissions values at points P10, P14 and P15. The point P10, presented the highest value of 2.56 and 2.59 (% vol of CH_4), respectively in the months of April and May. Point P14 had the highest value of 2.95 (% vol CH_4) in April and 2.28 (% vol CH_4) in May. Point P15 presented values of 2.78 and 2.72 (% vol of CH_4), respectively in the months of August and September, showing that methane production is higher in the most recently deposited wastes. Points P9, P10 and P11 showed higher values of carbon dioxide in the months of June, July, August and September, ranging from 2,500 to 3,500 ppm. The months of August and September presented high values of CO_2 that reached 5,000 ppm. Point P15 presented the highest value of 5,000 ppm of CO_2 in the months of August and September. The sulphur dioxide values showed a variation between the points of the measurement lines over the months. These results show that there is greater production of CO_2 in the most recently deposited wastes compared to the older and temperature-influenced waste in the hottest months of August and September than April and May. In the month of April, the first line of metering points presented higher values, decreasing considerably in the second and third lines, showing that the production of SO_2 is higher in wastes with longer deposition time than recent deposited wastes. In April, points P1 to P6 showed values above 100 ppm of SO_2 and dropped drastically in the point P7 to 3 ppm.

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