



Environmental Impact of Open Burning of Municipal Solid Wastes Dumps in Parts of Jos Metropolis, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author RED designed the study, carried out air quality measurements and wrote the first draft of the manuscript. Author ANC supervised the air quality measurements and carried out the literature searches. Author MIA also carried out air quality measurements and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Refuse dumpsites are found scattered within and outside cities in Nigeria and the open burning of these dumps is a common practice mainly as a waste and odour reduction measure. Open incineration of wastes emits dangerous gases into the atmosphere. The environmental and public health hazards related to open burning of wastes dumps have often been overlooked in most parts of Nigeria and there is limited documentation on this for the study area. This study is aimed at investigating the environmental effect of the burning of open refuse dumps at five locations within Jos Metropolis, Nigeria. Air quality in and around the study area were measured. The results showed that the oxygen levels for all the locations for the different conditions tested ranged between 14.2% and 17.5%. This showed that whether the dumpsites were burning or not the oxygen levels within the vicinity were below the comfortable level of 19.5%. CO levels ranged between 2ppm – 9ppm with the maximum value of 9ppm measured at Apatata when the refuse containing some plastics was burning. The values of CO may not be significant but the duration of

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exposure may make a difference on public health as most of the dumpsites are located within residential and commercial areas. CO₂ values, which ranged between 361ppm to 700ppm, are all higher than standard acceptable levels of 350ppm. The implication is that burning refuse in the open increases the quantity of CO and CO₂ in the atmosphere which will likely be of adverse health implication to the residents living close to such areas. It can be concluded that existence and burning of open refuse dumps contributed to the increase in values of air quality parameters measured around the dumpsites. To avert the harmful effects of indiscriminate dumping and burning of solid wastes within residential, commercial and other areas, it is recommended that there should be improvement in solid wastes management in Jos city and environs among other necessary measures.

Keywords: Open dumps; municipal solid waste; environmental impact; public health; plastic waste; refuse.

1. INTRODUCTION

Municipal solid wastes (MSW) that are improperly managed are capable of destroying the beauty of urban centers and they can have devastating effects on the environment and public health [1,2,3,4]. In most developing countries, solid wastes are mostly dumped in any available open space or informal community dumpsites [5]. Solid waste management is a major challenge in urban areas in Nigeria like most other developing countries because of financial, technological or infrastructural reasons [2,6,7]. The lack of services and infrastructure has often resulted in urban residents being confronted with wastes dumped all over the community in backyards, public spaces, drains, streets and streams.

Municipal solid wastes consist of domestic wastes generated by residents in addition to commercial wastes but they exclude industrial hazardous wastes and domestic sewage sludge. The composition of MSW is influenced by whether the area is residential or commercial, the economic level of the residents, season and weather, difference in the population of an area during the year, tourist places and culture of people living or doing business in the area [8]. Population increase, commercial activities and industrialization of major cities in the world have caused a rapid change and growth in the volumes and composition of wastes generated [7,3], leading to increasing difficulty in managing the wastes.

Plastic, polythene and cellophane wastes make up a reasonable percentage of the municipal solid wastes generated. These wastes are not biodegradable, that is why they are hazardous to the environment [9]. It takes plastics between 100 - 500years to degrade and unfortunately

most of these plastics are used just once and discarded [10]. The convenience of using plastics and cellophane for drinks and take-away packs from restaurants, commercial and other places comes with a high environmental cost because these wastes cause great harm to the environment in the form of air, land and water pollution [10,2]. These wastes have remained one of the most difficult categories of wastes yet to be properly managed not only in Nigeria but even globally. On a global scale, it is reported that plastics are poorly managed and plastic wastes have been one of the enduring environmental and health challenges of current time [11]. Within the study area a small percentage of the plastics are collected and recycled, and at the end they get to the point where they can no longer be recycled ending up in open dumps. During rainy season, they make their way into drains, gutters and canals which eventually result in blockages.

In a 2010 study carried out in Kano, a large city in northern Nigeria with population of over 10 million people, it was estimated that the composition of the solid wastes in the city were as follows: Polythene/cellophane (19%), Paper (12.7%), Metal (10%), Glass (8.7%), Plastics (11.3%), Fines (ash, dust and sand) (12%) and Miscellaneous (9%) [12]. This means that plastics, polythene and cellophane make up to 30.3% of the total quantity of the solid wastes. Another study by [13] showed that Lagos, also a large city in southern Nigeria with a population of over 10 million people produced about 10,000 metric tonnes of wastes daily, 12% (1,200 metric tonnes) of which were plastic wastes. A study conducted by [7] for five locations in Port Harcourt Rivers State again showed that the composition of nylon and plastics had an average of 15.7% with some limited margins of error.

One of the available researches on solid waste management in Jos North was an assessment of the performance of Plateau Environmental Protection and Sanitation Agency (PEPSA) in Jos [1]. The research reported that forty-five percent (45%) of land use types responsible for waste generation was residential while the general composition of the wastes was made up of 42% and 33% ashes and plastics respectively. Plastic pollution is a problem in Jos city from visual observation of open dumps in and around the city which are mainly on streets and close to residential and commercial areas.

Aliyu [12] rightly observed that 'throw away' (buy, use and throw away) culture that has developed over time in Nigeria is of great concern. This has resulted in massive refuse dumps and unsustainable waste management projects, especially in the cities [7]. The open burning of wastes is common practice mainly as a waste and odour reduction measure. Residents resort to constant burning of these wastes without a thought for the effect it has on their immediate environment. This could be the burning of waste within households, waste contained in public waste container inadvertently or advertently being set on fire, or systematic burning of waste at dumpsites. Some households burn their waste in their backyards as they consider it a cheap and easy way of disposing of their wastes. Other sources of urban air pollution within the study area which are mostly within commercial and residential areas are emissions due to transportation, fumes from diesel and petrol driven electric power generating sets and grinding machines, and other commercial activities. These sources can add to the air pollution within the study area especially within the busy part of the city centre. The effect of air pollution on human health may not be immediately felt by the population living within these urban areas but in the long run the aged and those with respiratory diseases may be effected.

Open incineration of wastes emits dangerous gases into the atmosphere. Significant amounts of greenhouse gases such as carbon dioxide, methane and particulate matter are released into the atmosphere as a result of open burning [2]. The open burning of waste could cause air pollution and health risks to those directly exposed to the smoke [14,15]. [16] reports an abundant release of poisonous gas substances into the environment as a result of burning of

polystyrene foam and obsolete e-wastes. [17] stated that some of the pollutants contained in the smoke of burning wastes include dioxins, furans, arsenic, mercury, polychlorinated biphenyls (PCBs), lead, carbon monoxide, nitrogen dioxide, sulphur dioxide, and hydrochloric acid while some of the pollutants can also be left behind in the ash. [17,18] observed that toxic gases such as nitrogen oxide and sulphur dioxide which are released into the atmosphere through burning of waste later accumulate and fall as acid rain. Open burning especially affects people with sensitive respiratory systems leading to respiratory diseases and the gases are carcinogenic [2]. [19] investigated the contribution of Municipal Solid Waste dump sites fire to atmospheric pollution and found that the levels of CO ranged between 133.7 and 141.6 ppm while the levels of CO₂ ranged between 401 ppm and 404.5 ppm among other parameters within the vicinity of the dump site fires were above regulatory limits. The research showed that dump site fires in the study area could put the health of people at risk especially the dump site workers that are regularly exposed to the thick smoke and pointed out there is a need to develop better practices with regard to municipal solid waste open dump site operation and emission control. Another study by [20] monitored seasonal variations in the CO₂ levels emitted at an open dump in a solid wastes management facility, Akure. Air CO₂ levels were monitored at seven locations within the facility three times every day for a week. The atmospheric CO₂ data in the study area showed seasonal and diurnal variations as evident in values of 438ppm to 630ppm in the dry season and 407.3ppm to 506.9ppm for wet season. These were all above the regulatory limit of 400ppm specified by the National guideline values. The study suggested periodic monitoring of air carbon dioxide levels keeping in mind the seasonal variations. The environmental and health hazards related to open burning of wastes dumps have often been overlooked in most parts of Nigeria and there is limited documentation on this for the study area.

This study is aimed at investigating the environmental effect of the burning open refuse dumps within some locations in Jos Metropolis, Plateau State, Nigeria. Specific objective of the study is to assess the air quality for different conditions in and around the open dumps where the wastes are often burnt in the open. The locations were within Jos North which is the urban and commercial centre in the Plateau

State capital, namely GadanBako, Rwang Pam, Langtang, Apata and St. Pirans.

2. MATERIALS AND METHODS

2.1 Study Area

Plateau State is located within the North Central part of Nigeria and Jos North is made up of the Jos city urban centre as well as some surrounding villages of historical importance in the State, such Naraguta village, Babale and some settlements such as Rikkos, Tudunwada, JentaAdamu, JentaMangoro etc. In the 2006 National Population Commission (NPC) census Jos North which has as approximate land area of 291km² had a population of 493,300 but now the population has grown much more than that. The city centre and the surrounding villages and settlements are all cosmopolitan in nature.

2.2 General View of Solid Wastes Disposal in Jos City

Solid wastes which include plastic and other non-biodegradable and biodegradable wastes are indiscriminately disposed of in the city of Jos.

Plates 1, 2, 3 and 4 show the type of menace that the indiscriminate open disposal of solid wastes poses, the eyesore to the beauty of the urban centres and the health hazards to the people who are exposed.

The open dumpsites were seen littered around town on busy streets, street corners, close to residences, commercial areas and schools, close to and inside water bodies such as streams running through residential areas, in abandoned mining pits, depressions and valleys etc. The waste collection containers that were seen to be available at most locations in Jos as reported by [21] are no longer in place at most of these locations. The waste disposal situation within Jos city and environs has deteriorated. Refuse are openly dumped indiscriminately at different locations as mentioned above and men of the environmental protection unit (PEPSA) are left with the unhealthy responsibility of manually collecting the wastes into trucks for disposal at designated locations outside the town from time to time (Plate 5). Most times these wastes are burnt on the streets by residents to reduce the quantity and odour because they can be left unattended for long periods.

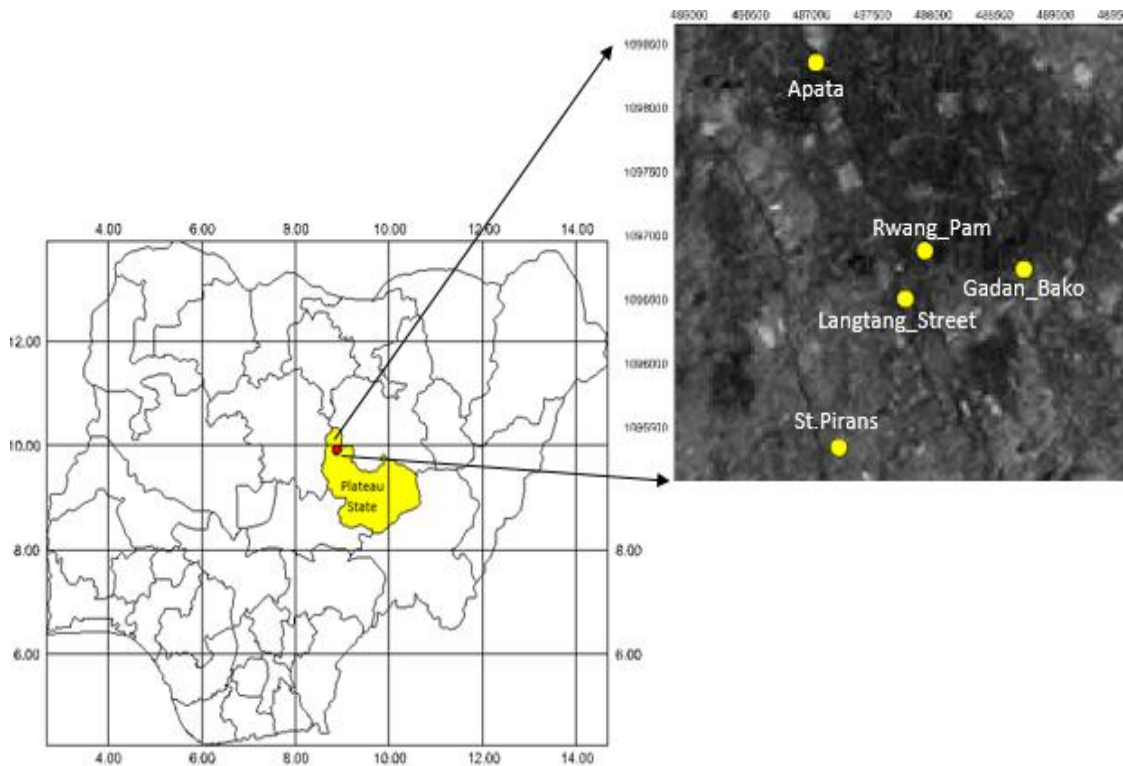


Fig.1. Map of Nigeria showing the study area



Plate 1. Open dumpsite at Apata by Government Secondary School Laranto, Jos



Plate 2. Plastic wastes dumped in an open drain at Fudawa, Jos



Plate 3. Open dumpsite at GadanBako

2.3 Air Quality Measurements at Dumpsites

The Lutron Electronic Enterprise Co., Ltd Anemometer with model number: AQ-9901SD (Plate 6) was used for air quality measurements. It is a 6-in-1 Air Quality Meter measuring CO₂, CO, O₂, Humidity, Dew point and Temperature.

- It can measure:
- CO₂ within the range of 0 – 4000ppm with a resolution of 1ppm and $\pm 5\%$ of reading accuracy
 - CO within the range of 0 – 1000ppm with a resolution of 1ppm and $\pm 5\%+2\text{ppm}$ accuracy

- O₂ within the range of 0 – 30% with a resolution of ±0.1% and 1% reading +0.2 % accuracy
- Humidity within the range of 5 – 95% with a resolution of 0.1% and ±3% reading +1% accuracy
- Temperature within the range of 0 – 50°C with a resolution of 0.1degree and ±0.8°C accuracy

Air quality parameters were collected within the month of December 2019 for five (5) locations within Jos city namely GadanBako, Apata, St. Pirans, Rwang Pam and Langtang Street. The parameters measured were: Oxygen (O₂), Carbon monoxide (CO), Carbon dioxide (CO₂) and Humidity.

Air quality data were collected for the following conditions around the open dump sites:

- I. Air quality measurement at the dumpsite when it was not burning.
- II. Air quality measurement at the dumpsite when it was burning.
- III. Air quality measurement 50m away from the burning dumpsite.
- IV. Air quality measurement 50m away in the opposite direction from the burning dumpsite.
- V. Air quality measurement at the open dumpsite with additional plastic, polythene and cellophane wastes included in the burning rubbish.

Data obtained from the above were used to investigate the air quality in and around the open dumps and view the differences in the concentrations of the parameters measured in the environment.



Plate 4. Open dumpsite at Rwang Pam



Plate 5. Men from PEPSA evacuating MSW on the street



Plate 6. Lutron air quality meter and GPS

3. RESULTS AND DISCUSSION

3.1 Results of Air Quality Measurements

The locational coordinates of points of data collection and their elevations with humidity are shown in Table 1.

The results of the air quality parameters of O₂, CO and CO₂ measured at the locations were plotted as bar charts and shown in Figs. 2, 3 and 4 respectively.

The oxygen (O₂) levels for all the locations for the different conditions tested ranged from between 14.2 and 17.5% as presented in Fig. 2. This shows that whether the dumpsites were burning or not the oxygen levels within the vicinity up to a distance of 50m away were still below the comfortable level of 19.5%. This suggests that the oxygen levels around the dumpsites were not adequate since the Respiratory Protection Standard considers any atmosphere with an oxygen level below 19.5% to be oxygen-deficient and immediately dangerous to life or health (Occupational Safety and Hazard Administration [22]. [22] recommends a minimum oxygen concentration of 19.5% required for breathing and a range of 19.5 - 23.5% for human and animal to maintain normal functions. Normally, humans breathe in air that is approximately 20.95% oxygen. Oxygen levels

that drop outside the safe zones can result into serious side effects. When the concentration of oxygen reduces from 19.5 to 16 percent, engaging in physical activity, will result in the failure of the cells to receive the oxygen needed to function correctly. When oxygen levels drop from 14 to 10% mental functions become impaired and respiration becomes intermittent. Any amount of physical activity at these levels can lead to the body becoming quickly exhausted. For levels of oxygen concentration below 6% humans won't even survive [23]. The worst oxygen level of 14.2% at Langtang Street can lead to mental functions becoming impaired especially due to long exposure where residents live close and around these open dumps.

For all the locations where air quality was tested, carbon monoxide (CO) ranged between 2ppm – 9ppm with the maximum value of 9ppm measured at Apatha when the refuse containing some plastics was burning as shown in Fig. 3. The values of CO may not be significant for most of the locations but the duration of exposure may make the difference on public health because most of the dumpsites are located within residential areas. Those that openly burn waste or are in areas where open burning takes place may be at risk of negative health effects. United States Environmental Protection Agency (EPA) has set National Ambient Air Quality Standards for six principal pollutants including CO. The standard for CO is represented in Table 2.

Table 1. Locations for air quality measurements

Location	Northings (Decimal Degrees)	Eastings (Decimal Degrees)	Elevation (m)	Humidity (%)
GadanBako	9.9225	8.8975	1179	16.4
Apata	9.9372	8.8819	1158	17.9
St.Pirans	9.9097	8.8836	1221	18.1
Rwang Pam	9.9238	8.8900	1206	16.7
Langtang Street	9.9203	8.8886	1206	16.4

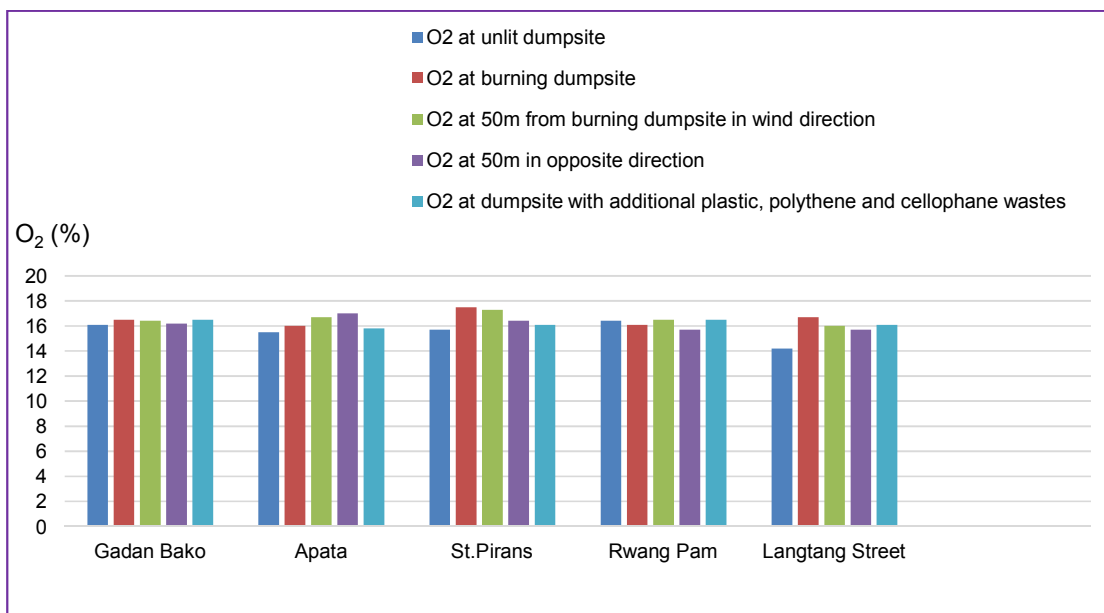


Fig. 2. Oxygen concentration measured at the dumpsites

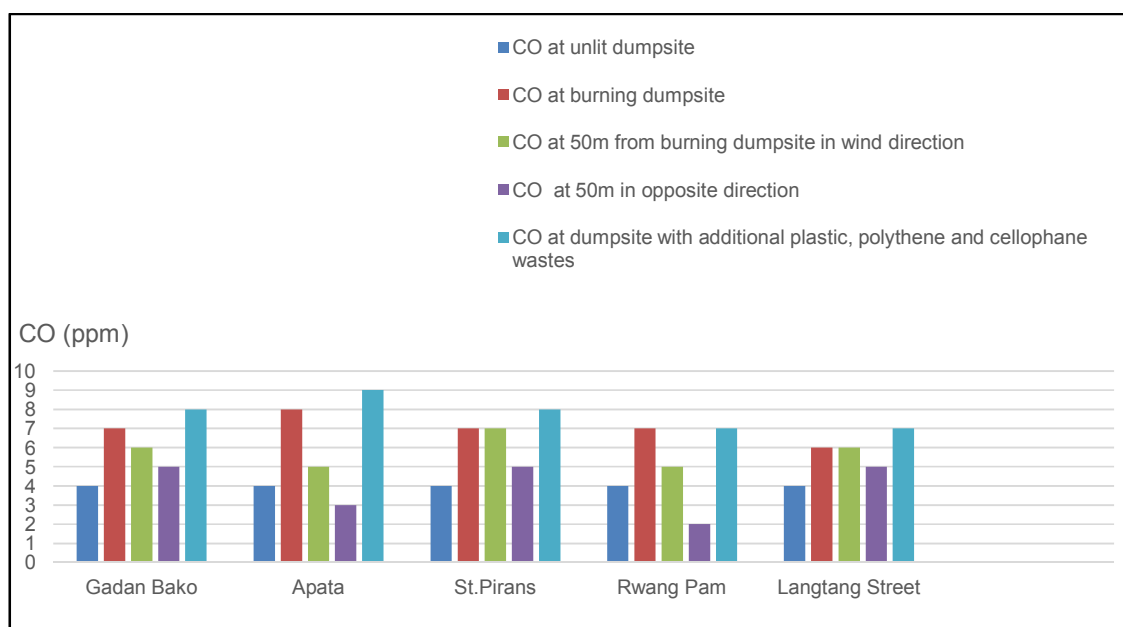


Fig. 3. Carbon monoxide concentration measured at the dumpsites

Table 2. WHO guidelines for carbon monoxide

Pollutant	*Primary/Secondary	Level	Exposure Period	Form
Carbon Monoxide (CO)	Primary	9ppm	8hours	Not to be exceeded once a year
		35ppm	1hour	

Source: (EPA, 2011)

**Primary standards provide public health protection, including protecting the health of sensitive populations such as asthmatics, children, and the elderly*

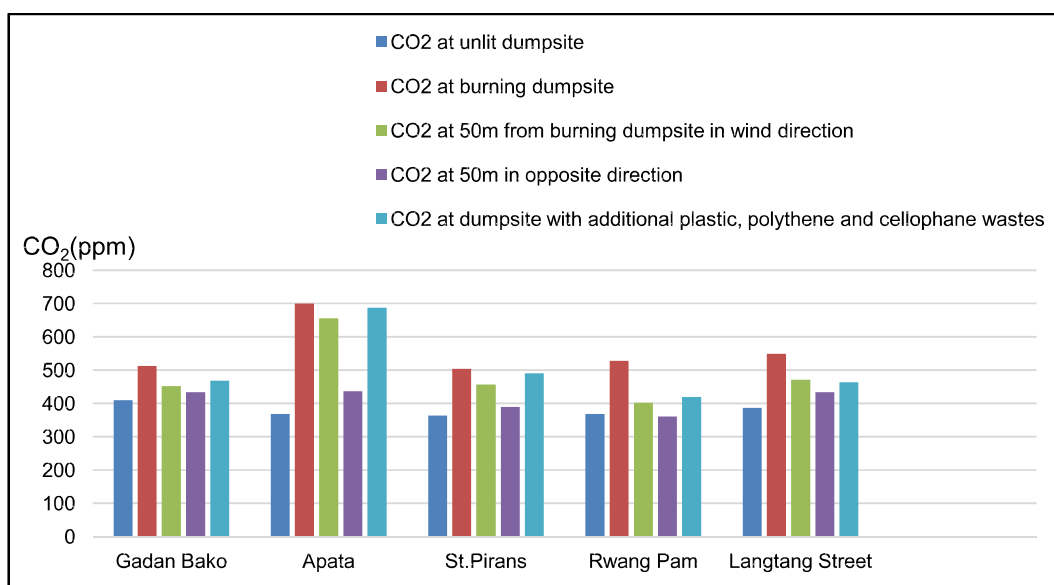


Fig. 4. Carbon dioxide concentration measured at the dumpsites

The CO levels were observed to have increased with the burning of refuse when compared to the values measured when the dumpsites were not on fire with estimated increases of 40.9%, 50%, 42.9%, 42.9% and 33.3% for GadanBako, Apata, St. Pirans, Rwang Pam and Langtang Street respectively. This increments are quite significant showing higher percentage increments of 50%, 55.6%, 50%, 42.9% and 42.9% respectively for the dumpsites burning with plastics inclusive. This shows that open burning of refuse can significantly increase CO concentration levels and refuse that have higher quantities of plastics further increase the CO concentration levels in the air posing higher risk to public health and environmental pollution. Plastics should therefore be separated from other refuse.

CO is one of the major pollutants that has significant effects on the environment, human beings and animals. It is a greenhouse gas and is usually released when something is burnt. Open burning of waste produces an estimated 37 million tons per year of CO gas, or 7% of global CO emissions. Open burning is responsible for

the release of a significant amount of CO into the atmosphere [2]. Breathing air with a high concentration of CO reduces the amount of oxygen that can be transported in the blood stream to critical organs like the heart and brain. Exposure to CO is of public health concern as it has some significant health impacts such as carbon monoxide poisoning. Complications due to CO poisoning arise when it is inhaled and builds up in the bloodstream. Minor symptoms of CO poisoning include headache, exhaustion, dizziness, nausea, shortness of breath and more. Exposure to high levels of CO causes health effects including Carboxy-haemoglobin and Cardiovascular diseases [24].

From the results of the measurements of CO₂ carried out, all of the values obtained for all the dumpsites were above 350ppm. The values ranged between 361ppm to 700ppm, with the highest value obtained being 700ppm for an open dump that was burning at Apata. The implication is that burning refuse in the open increases the quantity of CO₂ in the atmosphere which will likely be of adverse health implication

to the residents living close to such areas. Normally values above 1000ppm are associated with various levels of adverse health effects [25]. The charts in Fig. 4 show that burning dumpsites result in increase in the values of carbon dioxide when compared to the values of the same place when it was not on fire. The increases were estimated as 19.9%, 48%, 30%, 30.2% and 29.7% for GadanBako, Apata, St. Pirans, Rwang Pam and Langtang Street respectively. For the dumpsites burning with higher quantities of plastics the increments in CO₂ levels were 12.6%, 47.1%, 24.9%, 12.2% and 16.6% respectively. This shows that plastics in the burning refuse did not result in increased carbon dioxide concentration in the air.

Carbon dioxide (CO₂) is a greenhouse gas accounting for about 76% of all greenhouse gases worldwide as of 2010. Global yearly emissions of CO₂ due to open burning are large and estimated to be 1.4 billion tons per year which accounts for only about 5% of total global CO₂ emissions [2]. CO₂ is also an important pollutant of direct health concern in itself. A low value of CO₂ indicates that the natural environment is able to disperse emissions adequately, and this happens when there is no apparent point source of its emission. It can be responsible for the following health effects; headaches, asphyxiation, tingling sensation, sweating, dizziness, restlessness, loss of energy and concentration, increased heart rate, irritation to the mouth, throat, eyes and skin. Typical acceptable outdoor levels of CO₂ are in the range of 250-350ppm [26]. CO₂ levels in outdoor air normally range between 300 – 400ppm but they can be as high as 600 – 900ppm in metropolitan areas [27]. The values obtained are consistent with the usual values for metropolitan areas such as the study area.

Relative Humidity (RH) values were between 16.4% to 18.1% for the dumpsite vicinity when it was not burning as shown in Table 1. This is indicative of a very dry weather like the period when the measurements were taken in December 2019. Humidity is mainly effected by the time and season of the year and may not have a direct link with whether the dumpsite was on fire or not. Nevertheless, RH values could have the effect of electrostatic discharge and airborne infections resulting in skin and eye irritations, dry nasal passages and other discomforts. The outdoor relative humidity level that is considered comfortable is between 30% and 50% [28].

RH can lead to some health and wellness effects. High humidity can lead to overheating which can result in serious health problems like heat stroke and exhaustion. It causes the air to become more difficult to breath increasing risk of asthma attack. Low humidity results in the drying up of nasal passages. It can result in discomforts, skin and eye irritations which can lead to serious infection [29].

Temperature variations measured during collection of the air quality parameters are shown in Fig. 5. Variations in temperature from site to site depended on the time of measurements within the day, when temperatures are lower in the mornings and higher in the afternoons to early evenings, while the temperature for the different conditions of measurement mainly depended on the heat from the burning refuse mixing with the ambient temperature as a result of the blowing wind.

The average wind speed for Jos North in December 2019 was 10.9kmph (3.03m/s) with the maximum for the period being 14.8kmph and average wind gust = 17.7kmph [30]. Wind direction was North-East (NE). [31] suggests from their study that wind speeds in excess of 2.0m/s in urban areas have important role in atmospheric dilution. Pollutants tend to pile up in calm weather conditions when wind speeds are less than 2.0m/s but aid in increasing dispersion when speeds are higher. The result of linear regression by [32] in their analysis of wind circulation and air pollution in urban areas also showed that suspended particle and SO₂ concentrations declined slightly with increasing wind speed for some directions including NE though some directions showed a slight increase also. This means that for the harmattan period (December) when the study was carried out the wind speed was enough to improve air quality because of improved dispersion but that may not be so for other periods of the year.

Generally, the results showed that oxygen level was below expected level for normal respiration, CO levels though not at levels expected to be of adverse harmful effect is still much higher than 0.2ppm which is the natural CO concentration in the air and CO₂ showed values that are higher than standard acceptable levels since they were all greater than 350ppm, though the values were less than 1000ppm which means that there was good air exchange [23]. The relative humidity was low which was expected at that time of year in December. The values of all parameters

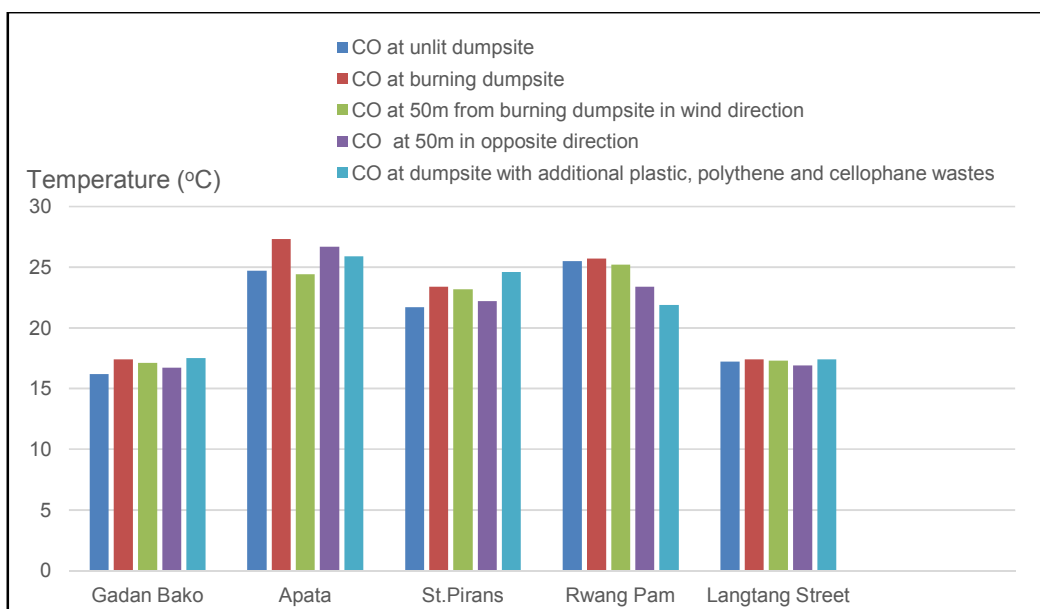


Fig. 5. Temperature variations measured at the dumpsites

measured were higher when the dumps were burning compared to when they were not on fire. Some studies carried out to assess the effect of open burning of municipal solid wastes on air quality have shown that the types of air pollutants and the levels of pollution are dependent on the composition of the solid wastes burnt. In a survey carried out by [33] in Korea to evaluate the emission levels of harmful substances from test combustion of individual types of domestic municipal solid waste, it was estimated that the average annual emissions of hazardous materials from frequent open burning were 71 tons for PM₁₀, 46.6 tons for PM_{2.5}, 914 kg for heavy metals, and 67 kg for PAHs with open burning creating nearly 0.44% of regional air pollution from PM₁₀. Similarly, [34] estimated annual levels of the pollutants from the open burning of MSW in Nigerian cities and found that wide varieties of both inorganic and organic air pollutants were released with associated human health and environmental impacts. [35] carried out an investigation to assess the amount of air pollution emitted from household solid waste open burning in Thailand and discovered that a total of 4.09 Mt/year of wastes were burnt in open areas. This resulted in the emissions of equivalent of carbon dioxide, carbon monoxide, sulfur dioxide, nitric oxide, and particulate matter values of 1247.3 kt/year, 103.0 kt/year, 1.2 kt/year, 7.4 kt/year, and 19.6 kt/year, respectively. These results show that there is a problem with solid waste management resulting

in open burning not only by residents but by government agencies and these have led to increase in air pollution.

4. CONCLUSION

It is evident that there is a serious problem with municipal solid waste disposal in Jos City and its environs. The reason is mainly as a result of population increase in the urban centre leading to enormous solid wastes generation. The use and throw away attitude of the residents have contributed immensely in the quantity of wastes generated everyday. Open burning leads to the emission of smoke and toxic fumes into the atmosphere. Open burning poses risks to the environment and public health as seen from the results of the carbon monoxide and carbon dioxide levels. It contributes to the greenhouse gases in the atmosphere. The open burning of these wastes can lead to or aggravate numerous heart and respiratory conditions that can shorten the lifespan of people within the vicinity of the dumps that inhale the undesirable gases constantly. The values of the parameters measured showed that some of them were at levels that could be of public health concern especially because the dumpsites were situated at locations that were close to residential areas. To avert the harmful effects of indiscriminate dumping of solid wastes within residential, commercial and other areas and burning of same which also directly effects the environment and public health, it is

recommended that there should be organized improvement in solid wastes management in Jos city and environs. The best method being the zero waste model which involves minimization of the total amount of waste through recycling, composting and other methods. Recycling and reuse should be encouraged by the Government through sensitization of the public on the importance of reusing plastics and cans or making other things out of them like the use of aluminium cans of drinks to make pots by the blacksmiths. This may not take place in a short time but must be a deliberate policy of government who will provide the infrastructure required and carry out continuous intensive sensitization of the populace to discard the use and throw away attitude. Considering the effects the open dumpsites have on public health and environment, people should be completely discouraged from setting open dumps within the vicinity of residential or commercial areas. The public should be enlightened on the need of separation of wastes, such as plastics, biodegradable or organic wastes, glasses etc during collection at residential, commercial and industrial areas for ease of management. Sanitary landfills and composting plants should be designed and constructed for use in solid waste disposal and treatment to reduce environmental pollution from open refuse burning. Public private partnerships should be strongly encouraged by the Government through the Ministry of Environment for solid wastes management.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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