THE MENACE OF SOLID WASTE MANAGEMENT IN WARRI, DELTA STATE: A SOURCE OF ENVIRONMENTAL POLLUTION OF EKPAN RIVER

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Abstract
This short communication examines municipal wastes disposal on shore and into rivers in Ekpan, Delta State as an environmental risk. The article explains many of the concepts and terminologies used in waste management. Many factors influence the impact or effect of municipal solid wastes on man and the environment. Appropriate waste management is therefore necessary to ensure the health of man and sustenance of the environment. Samples were collected in triplicate at different sampling stations from Ekpan River, Delta State in the Niger Delta ecological zone. The sampling stations include: the point of waste disposal, 500 m upstream, 500 m downstream and a control sample (1000 m). Results revealed that the samples were coloured, turbid (30—42 NTU) and high in suspended particles (25—50mg/L). Total iron (1.560 - 2.920 mg/L) was one of the heavy metals that recorded values above the specified Department of Petroleum Resources (DPR) and Federal Environmental Protection Agency (FEPA) regulatory limits of 1.00 mg/L. Similarly, cadmium exceeded the set limits in all the samples analysed. Concentration ranged between 1.650 mg/L (control) and 2.179 mg/L (Ekpan River DP). Although, copper and zinc had concentrations in compliance with local and International standards, significant concentrations were also recorded. The relative contents of these parameters in the river samples could be attributed to the different waste substances/types in the huge pile of waste thrown on the shores of the river; Humans and organisms in the environment are exposed daily to various toxins in different environmental media (air, water, soil). The effects of the waste on onions (Allium cepa), which could be acute or chronic depending on the level of exposure was considered for further evaluation in a different investigation. Ecotoxicology could be used as a tool to check such hazardous effects. It is expected that ecotoxicology would mature into a complementary tool to unravel the emerging environmental/waste management problems.

Key words: Municipal waste, environmental pollution, Rivers, water, contaminants.
1.0 Introduction

This information box has been prepared as a guide for waste management researchers. The document explains many of the concepts and terminologies used in waste management. By carefully reading this information it is hoped that good lines of communication are established to ensure appropriate waste disposal / management.

Waste is any inevitable/unwanted/undesired material or substance that must be disposed of in a controlled and environmentally friendly manner. It is also referred to as rubbish, trash, garbage, or junk depending upon the type of material. In living organisms, waste relates to unwanted substances or toxins that are expelled from them. Waste management is the human control of the collection, transportation, processing, recycling or disposal of different waste materials. This may include segregation, treatment and storage of the materials to be discarded. Materials generated by human activities are appropriately managed to reduce their effects on health and the environment (Rutala, 1993).

Waste disposal and management in Warri, Delta State is considered not very effective and the sanitary condition of the inhabitants is not taken into account. In Warri, any open land is regarded as a dump site for residents in the area. Once dirt is thrown on the land, it attracts more residents to dump their waste on that land until it become intolerable for the residents. The waste collectors in the area are not left out, since they consider the government approved open dump site along the Warri express road too far, they end up disposing of their waste in such open lands. A drive through the city of Warri leaves you with no doubt of the poor health and environmental condition there. The government law enforcers are not always there to carry out any functions and as such it is only the sign post with written information such as DO NOT DUMP REFUSE HERE. DEFAULTER WILL PAY A FINE OF =N=5,000.00 that you will see at such site. Rarely are offenders caught disposing of their wastes at such illegal sites.

The Local Government waste collectors make market traders place their waste on the dual carriage lane along major roads in the city. These wastes may not be collected until after four (4) to seven (7) days, leaving a horrible stench for the traders and passersby to contend with on a daily basis. Days after their weekly market, the wastes are still on our major roads, putting the city in a very unpleasant state. The wastes/litters bring vectors and rodents, as well as human scavengers who are always there to see what can be obtained from the left over of such wastes.

This study assessed water samples from Ekpan River along the Nigerian National Petroleum Corporation (NNPC) housing complex road, Ekpan, Delta State with the intention of ascertaining the effect of solid waste disposal on our waterways. This is with the view of ensuring that wastes are disposed of in a controlled and environmentally friendly manner that would not be detrimental to humans and organisms in the environment.

1.1 Waste Management Terminologies

Bio-medical waste: needles, syringes, bandages, cotton wool etc.

Contaminated: State of having been actually or potentially in contact with microorganisms. The term generally refers to the presence of microorganisms that could be capable of producing disease or infection.

Container: Vessel in which waste is placed for handling, transportation, storage and/or eventual disposal.

Disposal: Intentional burial, deposit, discharge, dumping, placing or release of any waste material into water bodies or land. Disposal is undertaken without the intention of retrieval.
**Domestic waste:** Municipal solid waste- vegetable waste, kitchen waste from galleys, household waste, human waste etc.

**Electronic waste** (E-waste): discarded electronic devices like computer, TV, phones, music systems etc.

**Encapsulation:** Filling a sharp container that is three-quarters full with cement or clay, which, after hardening can be disposed of safely in a landfill.

**Hazard:** Intrinsic potential, property or ability of any agent, substance or equipment to cause harm.

**Hazardous waste:** any toxic gaseous, liquid or solid waste (Reactive, Corrosive, Ignitable and/or Toxic), which due to its quantity, physical, chemical or infectious characteristics has the potential to harm human health or the environment when improperly handled, stored, transported, treated or disposed.

**Incineration:** Controlled burning of waste in a furnace (incinerator) at a high temperature for a short period of time, in order to reduce both its weight and volume. The burning of solid, liquid or gaseous combustible (burnable) wastes produce gases and residues (ash) containing little or no burnable material.

**Industrial waste:** Liquid waste- water used for different industries e.g. tanneries, distilleries, thermal power plants etc.

**Infectious waste:** The part of medical waste that is capable of causing infectious diseases.

**Metal waste:** unused metal sheet, metal scraps etc.

**Municipal waste:** General waste for collection by municipalities (e.g., local city or town authorities) generated mainly by households, commercial activities and street-sweeping.

**Office waste:** These are wastes generated from reprographics and other office services.

**Plastic waste:** Plastic bags, bottles, buckets, nylon etc.

**Radioactive waste:** Nuclear waste- unused materials from nuclear power plants etc.

**Sanitary landfill:** Engineered method of disposing of solid waste on land in a manner that protects the environment (e.g., by spreading the waste in thin layers, compacting it to the smallest practical volume and then covering it with soil at the end of each working day).

**Scavenging:** Manual sorting of solid waste at landfills and removal of usable material.

**Segregation:** Systematic separation of solid waste into designated categories.

**Sewerage:** System for the collection and transport of sewage, including conduits, pipes and pumping stations.

**Sharps:** Hypodermic needles, suture needles, scalpel blades, scissors, wire sutures, broken glass or any object that can cause a puncture or cut.
Waste management: All activities, administrative and operational (including transportation activities), involved in the handling, treatment, conditioning, storage and disposal of waste.

1.2 Sources of Municipal Solid Waste
Agriculture: crop, wood, logging, food waste, saw dust.
Commercial: offices, rental stores, entertainment centers, restaurants, hotels/motels, service stations.
Residential: single family homes, multiple family homes.
Industrial: industries, allied industries.
Institutional: schools, hospitals, prisons, libraries.
Municipal services: demolition and construction, street cleaning, land scarping; catch basin cleaning, parks and gardens, drainages, waste treatment residues.

1.3 Waste management hierarchy
The hierarchy of waste management principles has been set as: waste prevention, recovery and safe disposals. The waste hierarchy refers to the “4Rs” reduce, reuse, recycle and recover, which classify waste management strategies according to their desirability in terms of waste minimization. The aim of waste management hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.

1.4 Waste management techniques
The following are some of the waste management techniques that are available:
1. Landfill
2. Incineration
3. Composting
4. Mechanical biological treatment/Sewage treatment
5. Pyrolysis and Gasification
6. Thermal Desorption Unit (TDU)
7. Detoxifying Hazardous Waste

Of all the methods above, disposing of waste in a landfill is the most traditional method of waste disposal, and it remains a common practice in most countries. Landfills are usually established in disused quarries, mining voids or borrow pits. Disposing of waste in a landfill involves burying the waste. However, a properly-designed and well-managed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials. Older, poorly-designed or poorly-managed landfills can create a number of adverse environmental impacts such as wind-blown litter, attraction of vermin (e.g. rats, weasels, fleas, or cockroaches), and generation of liquid leachate. Another common byproduct of landfills is gas (mostly composed of methane and carbon dioxide), which is produced as organic waste, breaks down anaerobically (Baker, 1989).

1.5 Waste and Public health
The effects of uncontrolled waste disposal system render surface waters and the groundwater systems unsafe for human, agricultural and recreational use. There is a direct link between urban environmental degradation and public health problems in terms of water-related diseases such as diarrhea, dysentery, cholera and typhoid. Wastes give rise to offensive odour as a result of decomposition of the organic portion. This leads to a great discomfort and psychological imbalance to the people living or passing around the wastes dumps (Kumar et al., 2004). In this vein, open piles of waste should be avoided because they:
- Are a risk to those who scavenge and unknowingly reuse contaminated items,
- Allow persons to accidentally step on sharp items and injure themselves,
- Produce foul odors,
• Attract insects and animals (WHO, 1999).

2.0 Material and Methods

2.1 Description of the area
Warri is located in Delta State, which is in the Niger Delta ecological zone of Nigeria. The Niger Delta area is a prominent coastal region of the southern part of Nigeria facing the Atlantic Ocean, covering an area of about 70,000 square kilometres and comprising of nine states namely: Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers states. Warri is in one of the twenty five Local Government Areas (LGAs) of Delta State (Tamuno, 2005; Chinweze and Abiola-Oloke, 2009).

The city is subdivided into Warri South, Warri North and Warri South-East. Ekpan, which is less than 2 kilometers from Warri South, houses Ekpan River, which cuts across Warri River that empties into Escravos and Forcados Rivers and eventually into the Atlantic Ocean. Ekpan River is used mainly for fishing activities. The major ethnic groups in the region include Urhobo, Itsekiri, Ijaw, Isoko, Kwale amongst others. The city is very popular due to crude/petroleum drilling activities of most oil companies in the region (NPC, 2006; Nyananyo, 2007; Balouga, 2009).

2.2 Water sampling
Twenty four (24) water samples were collected in triplicates for physico-chemical parameters and heavy metals from Ekpan River. The water samples were stored in IL polyethylene bottles and cooled at 4°C for physico-chemical parameters while 1-2 mL of 1:1 nitric acid (AR) was added to those samples where heavy metals were determined (APHA2005; Gupta et al., 2009). The nitric acid was added to the water samples because it leads to a drop in pH therefore the loosely bonded ions can be released for determination.

2.3 Determination of metals in water samples
The water samples were digested using concentrated nitric acid (AR). The samples were mixed and 50 mL was transferred to a beaker to which 5 mL concentrated nitric acid was added and brought to a boil on a hot plate to the lowest volume possible (15 to 20 mL). Filtration was done after digestion. The filtrate was then diluted to volume with distilled water in a 50 mL volumetric flask (APHA 2005). The concentration of heavy metals was determined by running samples on atomic absorption spectrophotometer (AAS) (Shimadzu 6701F).

2.4 Waste handling and transport
Waste collection methods vary widely between different countries and states. Domestic waste collection services are often provided by local government authorities, or by private industries (FEPA 1991; DPR 2011). In Warri, this service is provided by the local government council, private owned companies, local mobile or cart men (commonly known as kole-kole). In some areas, the privately owned companies collect waste on a weekly or monthly basis depending on the arrangement or terms of agreement. The local mobile men use wheel burrows for house to house collection while the local government council collects only at market places or from dual carriage divider along major roads or streets in Warri.

The frequency cannot be determined but it is subject to weekly or when the heap of dirt becomes very huge. The local mobile men collect as low as twenty naira (N=20.00) and as much as two hundred to five hundred naira (N=200 - N=500.00) for each transaction. The privately owned companies collect from five hundred naira (N=500.00) and above on a monthly basis depending on the waste volume. However, the non-enforcement of laws and designated places for disposal still remains a major problem in Warri.
Before now, major streets in selected parts of Warri had the DESOPADEC refuse collection bins. These waste bins could be found only in Airport road, Ajaminoghan, Esisi junction, Warri prison yard, Ogunu areas. Streets in Okumagba layout, Eboh, Ogborioko, Odion road, Iyara areas and Warri main town do not have such bins. Most of the times, the bins would be filled to overflowing. Wastes and litters are stretched for a few yards away from the bin before the disposal team of DESOPADEC would come for collection leaving the environment in a deleterious state. However, these bins were taken out of the street, although various reasons were rumoured for the withdrawal, none of the correct information got to the layman on the street.

2.5 Waste Disposal Methods
Waste disposal methods include the following: ocean dumping, deep underground well, open dumping, river dumping, open burning, incineration, ocean trenches, composting, landfill etc. Considering the various waste disposal methods available, the method in practice in Warri, Delta State is open dumping. Open dumping has the advantage of being inexpensive however; the disadvantages include health-hazard - insects, rodents etc.; damage due to air pollution; ground water and run-off pollution, soil contamination amongst others.

2.6 Statistical analysis
The mean and standard deviation of the various parameters were calculated using analysis of variance (ANOVA) in excel windows. Pictorial representations were used to indicate conformance and non-conformance with local and International standards.

3.0 Results
The results for the analysis of the water samples from Ekpan River are presented in table 1, figures 1 and 2. In the River water analysis, the pH values reported ranged from 6.48 – 6.59 pH units. The highly coloured samples were turbid and there was high concentration of total suspended solids (TSS). Values obtained for turbidity (Fig 1) and TSS varied from 30 to 42 NTU and 25 to 50 mg/L respectively (Table 1). Significant concentrations were recorded for ammonia (2.04 – 3.32 mg/L) and phosphate (3.24 – 4.97 mg/L) (Table 1).

Table 1: Mean concentrations of physico-chemical parameters and heavy metals in Ekpan River

<table>
<thead>
<tr>
<th>Parameters</th>
<th>WHO Max Acceptable limit</th>
<th>WHO Max Allowable limit</th>
<th>DPR Limit</th>
<th>FME Limit</th>
<th>Ekpan River DP</th>
<th>Ekpan River DS</th>
<th>Ekpan River US</th>
<th>Ekpan River (1 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.5-8.5</td>
<td>6.5-9.2</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
<td>6.5±0.03</td>
<td>6.5±0.01</td>
<td>6.5±0.01</td>
<td>6.59±0.02</td>
</tr>
<tr>
<td>Temperature, °C</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>29.5±0.01</td>
<td>30.0±0.01</td>
<td>30.0±0.01</td>
<td>30.0±0.01</td>
</tr>
<tr>
<td>Conductivity, μS/cm</td>
<td>250</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>97.10±0.17</td>
<td>92.90±0.12</td>
<td>90.48±0.14</td>
<td>84.0±0.10</td>
</tr>
<tr>
<td>TDS, mg/L</td>
<td>1500</td>
<td>1500</td>
<td>2000</td>
<td>38.05±0.14</td>
<td>46.50±0.10</td>
<td>46.50±0.11</td>
<td>46.50±0.11</td>
<td>46.50±0.11</td>
</tr>
<tr>
<td>Salinity, mg/L</td>
<td>1000</td>
<td>2000</td>
<td>600</td>
<td>38.05±0.14</td>
<td>34.43±0.11</td>
<td>31.36±0.11</td>
<td>31.36±0.11</td>
<td>31.36±0.11</td>
</tr>
<tr>
<td>Nitrate, NO3-N, mg/L</td>
<td>10</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.77±0.01</td>
<td>0.52±0.01</td>
<td>0.45±0.01</td>
<td>0.23±0.01</td>
</tr>
<tr>
<td>Sulphate, mg/L</td>
<td>2000</td>
<td>4000</td>
<td>N/A</td>
<td>N/A</td>
<td>9.84±0.01</td>
<td>8.62±0.09</td>
<td>7.43±0.07</td>
<td>6.24±0.07</td>
</tr>
<tr>
<td>Bicarbonate, mg CaCO3/L</td>
<td>500</td>
<td>5000</td>
<td>N/A</td>
<td>N/A</td>
<td>0.61±0.01</td>
<td>0.43±0.01</td>
<td>0.32±0.01</td>
<td>2.44±0.01</td>
</tr>
<tr>
<td>Total Hardness, mg CaCO3/L</td>
<td>500</td>
<td>5000</td>
<td>N/A</td>
<td>N/A</td>
<td>31±0.4</td>
<td>32±0.4</td>
<td>30±0.4</td>
<td>24±0.2</td>
</tr>
<tr>
<td>Calcium, mg CaCO3/L</td>
<td>5000</td>
<td>2000</td>
<td>N/A</td>
<td>N/A</td>
<td>20±0.2</td>
<td>17±0.2</td>
<td>16±0.2</td>
<td>12±0.1</td>
</tr>
<tr>
<td>Magnesium, mg CaCO3/L</td>
<td>5000</td>
<td>5000</td>
<td>N/A</td>
<td>N/A</td>
<td>8±0.1</td>
<td>8±0.1</td>
<td>6±0.1</td>
<td>4±0.1</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>50±4.0</td>
<td>34±2.0</td>
<td>30±2.0</td>
<td>25±1</td>
</tr>
<tr>
<td>Hydrogen sulphide, mg/L</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.13±0.04</td>
<td>0.10±0.01</td>
<td>0.08±0.01</td>
<td>0.06±0.01</td>
</tr>
<tr>
<td>Ammonia, NH4-N, mg/L</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>3.32±0.01</td>
<td>2.87±0.01</td>
<td>2.67±0.01</td>
<td>2.04±0.01</td>
</tr>
<tr>
<td>Phosphate, mg/L</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>4.97±0.3</td>
<td>4.66±0.3</td>
<td>4.23±0.2</td>
<td>3.24±0.2</td>
</tr>
</tbody>
</table>
Values are means of 3 replicates

DP = point of waste disposal
DS = Downstream
US = upstream
TDS = Total dissolved solids
TSS = Total suspended solids

The values reported for ammonia and phosphate could be attributed to the different waste dump as well as washing activities on the shore of the River. Total iron (1.560 – 2.920 mg/L) has values above the WHO/DPR/FFPA regulatory limits of 1.00 mg/L. Similarly, cadmium exceeded the set limits in all the samples analysed. Concentration ranged between 1.650 mg/L (control) and 2.179 mg/L (Ekpan River DP) (Fig 2).

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**Fig.1: Mean concentrations of turbidity in Ekpan River**

**Fig.2: Mean concentrations of heavy metals in Ekpan River**
Although, copper and zinc had concentrations in compliance with local and International standards, significant concentrations were also recorded. These heavy metal loads could be attributed to the kind of wastes disposed along the river bank coupled with rain water runoff that carry the leachate into the River. The other heavy metals recorded relatively moderate concentrations. Besides the above mentioned abnormalities, all other parameters had concentrations that were within the various WHO/DPR/FEPA stipulated ranges and limits.

4.0 Discussion

It has been reported that high concentrations of heavy metals could adversely affect aquatic organisms resulting in retarded growth, reduced reproduction and abnormal response to the opposite sex (Ezemonye and Enuneku, 2006). Waste generated if not properly managed could contaminate our water ways to the extent of leaching toxic substances into the water. The result of which could lead to damage of organisms in such environment. There could also be gradual seepage into underground water bodies with a transfer of these harmful substances (Gupta et al., 2009).

Similarly, high TSS can cause an increase in surface water temperature, because the suspended particles absorb heat from sunlight. The decrease in water clarity caused by TSS can affect the ability of fish and other aquatic organisms to see and catch food. Suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development. High TSS in a water body can often mean higher concentrations of bacteria, nutrients, pesticides, and metals in the water (Degen and Nussberger, 1956; World Bank & Government of the Netherlands, 1999).

In addition, daily exposure of aquatic organisms can lead to bioaccumulation of toxicants, and besides the detrimental effects it could cause these delicate species, man may also be affected since they are the end consumers of these viable species.

The aesthetic value of the rivers would also be compromised, especially if these shores are to be used for recreational purposes. Currently, Ekpan River is used for fishing activities, and organisms from such catch would enter the market and be consumed by man without knowledge of the environment the organisms were obtained.

Waste management is very poor in Warri, Delta State and there is a serious need to address the prevailing issues surrounding proper waste disposal so as to safeguard our delicate aquatic environment, the organisms that thrive in it and finally man.

4.1 The way forward

The following could be undertaken to improve the waste management situation in Warri, Delta State.

- Waste disposal along dual carriage line in major cities in the state should be discouraged.
- Dumping of waste on the shores and into rivers especially Ekpan River should be prohibited.
- In light of the above, waste bins should be placed at every 500 m distance in all public places and streets.
- The approved government open dump site should be converted to an engineered landfill which is practiced in most countries of the world.
- Incinerating (burning) items to destroy the item as well as any microorganisms. (This is the best method for disposal of contaminated waste. Burning also reduces the bulk volume of waste and ensures that the items are not scavenged and reused).
- Local government regulators should ensure that waste generated should be collected daily at the disposal sites for further segregation, treatment or disposal.
- The public should be enlightened on the appropriate waste disposal, health impact and environmental damage.
- Refuse collectors (private and government) should ensure that the waste gets to the final disposal point.
- Interlocking tiles should be used in all compounds to reduce the amount of waste getting into the gutters.
• Users of sachet water papers and other wrapped edible materials should ensure proper disposal into waste bins instead of throwing them along streets and roads.
• Training and awareness should be conducted for local Government regulators to ensure that Waste Management objectives are implemented.
• Waste management awareness should be made known to the public through short presentations, jingles and the use of posters at strategic locations.
• Open piles of waste should be avoided.
• Use of plastic or galvanized metal containers with tight-fitting covers for contaminated wastes.
• Place waste containers close to where the waste is generated and where it is convenient for users (carrying waste from place to place increases the risk of infection for handlers).
• Wash all waste containers with a disinfectant cleaning solution (0.5% chlorine solution plus soap) and rinse with water regularly.
• When possible, use separate containers for combustible and noncombustible wastes prior to disposal.
• Use personal protective equipment (PPE) when handling wastes (e.g., heavy-duty utility gloves and closed protective shoes).
• Wash hands or use a waterless, alcohol-based antiseptic hand rub after removing gloves used in handling wastes.

As a further step, investigation to assess the effect of the waste effluent on onions (*Allium cepa*) would be researched.

5.0 Conclusion
Whilst techniques and legislation are constantly evolving to improve our waste management performance, the volumes of waste we produce also keep increasing. Waste management has become part of our survival strategy. If we have to live, we will produce waste. If we do not treat waste, it will choke us. Waste is a problem, waste management is the solution.

6.0 References


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