ASSESSMENT OF SOME MICRO-ORGANISMS AND PHYSICO-CHEMICAL PROPERTIES OF FLOODWATERS IN SOME MAJOR STREETS IN BENIN CITY, NIGERIA

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Abstract
This paper investigated microorganisms and physico-chemical properties of floodwaters in some major streets in Benin City. Floodwater samples were collected from the selected streets and taken to the laboratory for analysis using AAS Model-Solaar 969 Unicam series with Air Acetylene flame. The increasing trends of annual and October rainfall justified the timing of this study. Samples revealed colour (CTU) value of >550 in Ugbowo-Lagos Road, New Benin-Ugbowo Road and Textile Mill Road while the lowest value was recorded for Siluko Road. The highest PH at room temperature was recorded in Siluko Road (6.90) and lowest in New Benin-Ugbowo Road (8.70) while conductivity (µs/cm) was highest in New Benin-Ugbowo Road (519) and lowest in Siluko Road (203). While the highest Cl⁻ (mg/l) was recorded against Ugbowo-Lagos Road (141.65), Textile Mill Road revealed the lowest value (33.02). The highest and lowest dissolved CO₂ (mg/l) were recorded against Ugbowo-Lagos Road (51.64) and Textile Mill Road (8.80) respectively. Similarly, Fe (mg/l) was highest in Ugbowo-Lagos Road (4.39) and lowest in Textile Mill Road (0.15). Only the relationship between Cl⁻ and conductivity was significant (P < 0.05). Aerobic mesophilic count of the samples were highest in Upper Mission Road (5 x 10⁴ cfu/ml) and lowest in Ugbowo-Lagos Road (2 x 10³ cfu/ml) while coliforms were highest and equal in Siluko, Textile Mill and Upper Mission Roads with at (4 x 10³ cfu/ml) and lowest in Ugbowo-Lagos Road (2.3 x 10³ cfu/ml). With the exception of Siluko Road with a value of (2 x 10⁵ cfu/ml), no trace of Escherichia. coli was found in samples collected from other roads. Similarly, no traces of Enterococcus and yeast/fungi were detected in all the samples. It is concluded that the physico-chemical conditions of floodwaters may have contributed to vehicular corrodiability while the Aerobic mesophilic and Coliforms states of floodwaters could pose health risks to pedestrians. It is recommended that the on-going urban renewal should make provisions for drainage and in the interim, motorists and pedestrians should avoid contacts with floodwaters to reduce corrosion of the metallic components of their vehicles and health hazards.

Keywords: Rainfall dynamics, floodwater, physico-chemical properties, micro-organisms and Benin City facilities.

Introduction
Over the years, increasing urbanization has created diverse environmental challenges due to growing demand for social infrastructures as a result of demographic pressure. Significant among these challenges in urban areas across Nigeria is flooding which is due to concretization of the urban landscape which renders it impervious to rainwater. Although channel constriction accentuates flow levels in terms of depth and width (Betts, 1999), the exposed nature of most drainage systems make them susceptible to siltation and blockage. Also critical to flooding is poor waste disposal which coupled with siltation obstructs available drainage
only increased but are occurring in different ecological zones globally which makes it a ubiquitous phenomenon. The yearly occurrence of flood incidences in Benin City has elicited research interests. Odemerho (1988) examined flooding from a causal perspective; Omiunu (1988) addressed flooding in relation to vehicular traffic while Atedhor et al (2011) focused on flood impacts and adaptation strategies. No study has examined the microbial and physico-chemical properties of floodwaters in Benin City, Nigeria in order to make inference on its implications on the metallic components of vehicles, concretized surfaces and pedestrians who repeatedly wade through floodwaters. This paper therefore examines some microbial and physico-chemical characteristics of flood water in some major streets in Benin City.

The study area
Benin City is located at latitude 06.19°Nand longitude 0.5.06°E with an average elevation of 77.8m above sea-level. It is a pre-colonial city, the capital of defunct Bendel State and present Edo State. Benin City is underlain by sedimentary formation of the Miocene-Pleistocene-age usually referred to as the Benin formation (Odemerho, 1988). Owing to the growing population size (projected to be 1.3 million by 2010) of the city and being a gateway to the eastern and south south states, its major streets are usually busy with high vehicular traffic. Benin City lies in the Humid Rainforest belt of Nigeria with a wet season which lasts 8 months beginning from March to October (Odekunle, 2011). Characteristically, rainfall in Benin City are usually of high intensity and double peaked with maxima rainfall usually in the months of July and September with a little dry spell typically in August. As in other parts of Nigeria, rainfall pattern in Benin City is controlled by the northward migration and retreat of the Inter-Tropical Discontinuity (ITD) which Ilesanmi (1971) described as “a region where the hot and dry northern air, sometimes marked by negative dew, is separated from the cool and moist southern air often characterized by dew points >70F.” The latitudinal location of Benin City therefore, makes it to experience long wet season because of the northward location of the ITD in relation to Benin City for most parts of the year which makes flood incidence a recurrent decimal in different parts of the City.

Methodology
This study examined the micro-organisms and physico-chemical properties of floodwaters in some major streets in Benin City, Nigeria. Since saturation of soil pores, among others, contributes to overland flow, samples of floodwaters were collected in the month of October which is preceded by months of high rainfall intensities. To further justify the study and the timing for the collection of floodwater samples, monthly rainfall data (1941-2010) were collected from the archives of the Nigerian Meteorological Agency, Lagos. The annual rainfall was computed and to determine the amount of rainfall received in the month of October in relation to rainfall in other wet months, the average monthly rainfall for each of the months that make up the wet season (March to October) from 1941 to 2010 were computed. The annual and October and the monthly distribution of rainfall during the wet season were graphically depicted. In order to determine the microbial and the physico-chemical properties of floodwaters in five selected major streets (Ugbowo-Lagos Road by Tom Line Construction Company, New Benin-Ugbowo Road by Okhorho Junction, Textile Mill Road by Second West Junction, Upper Mission and Siluko Road by Teachers House) in Benin City, water samples were collected from flood pondages and taken to the laboratory for analysis. AAS Model-Solaar 969 Unicam Series with Acetylene flame was used. The physico-chemical parameters investigated are: colour (ctu), hydrogen ion (pH) at room temperature, conductivity (µs/cm), chloride (Cl⁻) (mg/l), Carbon IV Oxide (CO₂) (mg/l) and iron (Fe) (mg/l). The relationship between the physic-chemical properties of the floodwaters was tested using multiple product moment correlation. The microorganisms investigated are: Coliform (cfu/ml), Escherichia coli (cfu/ml), Enterococcus faecalis (cfu/ml), Aerobic mesophylic (cfu/ml) and fungi/yeast (cfu/ml).

Rainfall dynamics in Benin city
Figure 1 shows increasing annual trend of rainfall in Benin City especially since 1987. Like other humid rainforest stations, rainfall in Benin City is bimodal with peaks occurring in July with mean rainfall of 352.5 mm and September with mean
value of 349.8 mm (Figure 2) which represent 17.6 % and 17.4 % contribution to the wet season rainfall respectively. Meteorologically, flood incidences are triggered by heavy rainfall intensity which often leads to saturation of soils pores. Atedhor et al (2011) have noted that the combined effect of meteorological and other environmental factors coupled with anthropogenic factors of which indiscriminate dumping of refuse and poor land use control accentuate flooding in Benin City. The siltation of drainage systems coupled with saturation of soil pores due to the preceding months of heavy rainfalls leave most roads in Benin City flooded despite the relatively lower rainfall in the month of October (249.3 mm) which represents only 12.4 % of the wet season rainfall. The resultant floods disrupt intra-city vehicular movements along the affected major streets in Benin City (Omiunu, 1988). In extreme cases, when there is complete disruption of vehicular movements, pedestrians are forced to walk across the floodwater thereby resulting to direct contacts with the contaminated floodwaters.

Figure 1: Annual and October Rainfall in Benin City

![Annual and October Rainfall in Benin City](image)

Figure 2: Mean monthly distribution of rainfall (mm) during the wet season in Benin City (1941-2010)

![Mean monthly distribution of rainfall](image)

Physico-chemical properties of floodwater

The floodwater samples revealed >550 colour value in Ugbowo-Lagos Road by Tom Line Construction Company, New Benin-Ugbowo by Okhoro Junction and Textile Mill Road by Second West Junction. Siluko Road by Teachers House had the lowest colour value of 417 while that Upper Mission Road was 439 (Figure 3).

![Floodwaters colour (ctu) in the selected streets in Benin City](image)

Figure 3: Floodwaters colour (ctu) in the selected streets in Benin City
PH values show that floodwater sample from Siluko Road by Teachers House was most acidic with value of 6.90 followed by Upper Mission Road with PH value of 7.0 while New Benin-Ugbowo Road by Okhoron Junction had the lowest floodwater acidity with PH value of 8.70 (Figure 4). Although floodwater is classified as waste water, the pH values of the water samples fall within WHO (World Health Organization) range of 6.5-8.5 for drinking water with the exception of Okhoron with pH value of 8.7. The high acidity of the floodwater sample from Teachers House (6.9) is an indication of the presence of metals, particularly toxic metals (Akinbile and Yosuff, 2011).

Figure 4: Floodwaters pH at room temperature in the selected streets in Benin City

The floodwater at Okhoron Junction had the highest conductivity with a value of 519 while the lowest conductivity value was recorded for Siluko Road by Teachers House at 203 (Figure 5). The relatively high conductivity recorded in floodwater at Okhoron Junction, Benin-Lagos Road by Tom Line Construction Company and Upper Mission Road could be blamed on effluent from markets, domestic discharge and run-off from vegetated surfaces. According to Abdul-Razak et al (2000), these sources increase the concentration of ions.

Figure 5: Conductivity of floodwaters in the selected streets in Benin City

Figure 6 shows that the highest dissolved CO$_4$ value was recorded in floodwater sample from Ugbowo-Lagos Road by Tom Line Construction Company with value of 51.64 while the lowest value was recorded for Textile Mill Road (8.80). The high floodwater pH value recorded in Siluko Road by Teachers’ despite a low CO$_4$ value suggests the derivation of its acidity from the vegetal cover of the area since this aid the formation of organic acid (Oyegun, 1997).
Dissolved Cl\textsuperscript{−} was observed to be highest in Ugbowo-Lagos Road by Tom Line Construction Company (141.65 mg/l) while the lowest value was in Textile Mill Road by Second West Junction (33.02 mg/l). The Cl\textsuperscript{−} level of the floodwater samples are below the WHO maximum permissible limit of 250 mg/l. The relatively high level of Cl\textsuperscript{−} in Benin-Lagos Road by Tom Line and Okhoro Junction indicates the presence of silicate rich minerals, highway salt, sewage, drainage, and leachates from garbage dumps. These sources have been reported as channels through which chloride gets into waters by (Government of Saskatchewan, 2010; Akinbile and Yosuff, 2011).

Figure 6 reveals that the floodwater at Ugbowo-Lagos Road by Tom Line Construction Company has the highest concentration of Fe (4.39 mg/l) while Textile Mill Road has the lowest concentration of Fe (0.15 mg/l). The disparities in the values of the different physico-chemical parameters investigated show that they vary spatially in Benin City. The reddish-brown colour of floodwaters is derived from the sand of the Benin formation which is typical of oxidized soils identical with dirt (Oyegun, 1997).

The correlation analysis of the physico-chemical properties of the floodwaters reveals significant relationship (p < 0.05) between conductivity and Cl\textsuperscript{−} (Table 1). This result confirms the similar patterns of conductivity and Cl\textsuperscript{−} in all the floodwaters.

Table 1: Correlations of physico-chemical properties of floodwaters

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>Conductivity</th>
<th>Carbon IV Oxide</th>
<th>Chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Pearson Correlation</td>
<td>Sig. (1-tailed)</td>
<td>N</td>
<td>1</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Pearson Correlation</td>
<td>Sig. (1-tailed)</td>
<td>N</td>
<td>.635</td>
</tr>
<tr>
<td>Carbon IV Oxide</td>
<td>Pearson Correlation</td>
<td>Sig. (1-tailed)</td>
<td>N</td>
<td>-.140</td>
</tr>
<tr>
<td>Chloride</td>
<td>Pearson Correlation</td>
<td>Sig. (1-tailed)</td>
<td>N</td>
<td>.418</td>
</tr>
</tbody>
</table>

\textsuperscript{2}For this correlation, the absolute value of the correlation coefficient is given.
Micro-organism contamination of the floodwaters

Table 2 shows the microbiology laboratory results of the floodwater samples. Aerobic mesophilic counts were higher in Upper Mission Road ($5 \times 10^4$) and Textile Mill Road ($5 \times 10^3$) while the lowest value was recorded in Ugbowo-Lagos Road by Tom Line Construction Company ($2 \times 10^3$). Coliforms were highest in New Benin-Ugbowo Road by Okhoro Junction, Textile Mill Road and Upper Mission Road at $4 \times 10^3$ while the lowest was recorded Ugbowo-Lagos Road by Tom Line Company at $2 \times 10^3$. Escherichia coli was nil in all the water samples with the exception of sample from New Benin-Ugbowo Road by Okhoro Junction with a value of $2.3 \times 10^3$. No trace of Enterococcus faecalis and fungi/yeast were detected in all the floodwater samples. The high concentration of Cl$^-$ and CO$_4$ could be responsible for the absence of Escherichia coli (with the exception of Siluko Road), Enterococcus faecalis and fungi/yeast in the floodwaters. The Aerobic mesophilic, Coliform and Escherichia coli suggest in the floodwaters suggest microbial pollution mainly due to anthropogenic activities. Poor adherence to waste disposal regulations which often lead to the silting of drainage facilities could be responsible for the level of pollution. Accidental intake of the floodwaters especially by drowning children could pose adverse health consequences.

Table 2: Micro-organism contamination of floodwaters

<table>
<thead>
<tr>
<th>S/N</th>
<th>Flood sample</th>
<th>Aerobic mesophylic (cfu/ml)</th>
<th>Presumptive coliforms (cfu/ml)</th>
<th>Escherichia coli (cfu/ml)</th>
<th>Enterococcus faecalis (cfu/ml)</th>
<th>Yeast/Fungi (cfu/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ugbowo-Lagos Road by Tom Line Construction Company</td>
<td>$2.0 \times 10^3$</td>
<td>$2.3 \times 10^3$</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>2</td>
<td>New Benin-Ugbowo Road by Okhoro Junction</td>
<td>$4.0 \times 10^5$</td>
<td>$4.3 \times 10^3$</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>3</td>
<td>Siluko Road by Teachers House</td>
<td>$4.0 \times 10^3$</td>
<td>$3.0 \times 10^3$</td>
<td>$2.0 \times 10^2$</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>4</td>
<td>Textile Mill Road by Second west Junction</td>
<td>$5.0 \times 10^3$</td>
<td>$4.0 \times 10^3$</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>5</td>
<td>Upper Mission Road</td>
<td>$5.0 \times 10^4$</td>
<td>$4.0 \times 10^4$</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Implications

The flood-prone major streets in Benin City selected in this study enjoy high vehicular traffic. The pH values of the floodwater samples, especially that of Siluko Road by Teachers House, the high amount of Cl$^-$ mainly in Ugbowo-Lagos Road by Tom Line Construction Company and New Benin-Ugbowo Road by Okhoro Junction, the high level of dissolved CO$_4$ in Ugbowo-Lagos Road by Tom Line Construction Company could trigger the corrosion of the metallic components of the huge vehicular traffic that ply the busy major streets of Benin City. The dissolution of CO$_4$ in water leads to the formation of carbonic acid which aids corrosion of vehicles and weaken the cohesiveness of the asphaltic makeup of the roads. Also, the high conductivity and the Cl$^-$ of the floodwaters, especially in New Benin-Ugbowo Road by Okhoro Junction and Ugbowo-Lagos Road by Tom Line Construction Company are catalysts for vehicular corrodibility. Omiunu (1995) earlier classified Benin City among Nigerian cities with high indices of vehicular corrodibility with reference to Peugeot series. It is instructive to note that these physico-chemical parameters and the activities of microorganisms in the floodwaters are not isolated in producing favourable corrosive solutions. Rather, it is the combined reaction of these factors that attack the metallic components of vehicles and also weaken
the binding force of roads. Saravanakumar and Dhinakaran (2010) have reported that saline water affect the properties of the concrete materials. Consequently, the saline state of the floodwaters especially at Benin-Lagos Road could lead to the failure of the road as well as the drainage system which are mainly concrete.

The contamination of the floodwaters with microorganisms could pose health risks to stranded pedestrians who wade through the floodwaters, especially when the degree of flooding render the streets impassable to vehicular traffic which occasion disruption of intra-city transport services. Since water has been identified as principal agent for many tropical diseases (Alm et al, 1993), contact with floodwater could pose health risks to pedestrians, especially dermatological infections and typhoid fever when accidentally gulped. As Shittu et al, (2008) have argued, the possibility of ingesting infective dose of disease causing microorganism is very high considering the fact that water borne pathogens generally have low infective dose. Furthermore, increasing rainfall and flooding provide breeding ponds for mosquitoes (de Sylva, 1993).

Conclusion
This paper examined the some microbial and physico-chemical properties of floodwaters in some major streets in Benin City. Based on the findings, it is concluded that floodwaters in major streets in Benin City are contaminated with Aerobic mesophilic and presumptive coli with no trace of Escherichia coli (with the exception of Teachers House), Enterococcus and yeast/fungi. The high concentration of Cl\(^{-}\) and CO\(_3\) may have contributed to the absence of Escherichia coli (with the exception of Teachers House), Enterococcus faecalis, and Yeast/Fungi. The floodwaters are also toxic physico-chemically and only the relationship between Cl\(^{-}\) and conductivity is significant. It is therefore recommended that the on-going urban renewal should make adequate provisions for drainage and in the interim, motorists and pedestrians should avoid contact with floodwaters by making use of alternative routes to reduce the corrosion of the vehicular components of their vehicles and health hazards.

References


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