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Full Length Research Paper

Assessment of heavy metals in urban highway runoff from Ikorodu expressway Lagos, Nigeria

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The distribution of heavy metals in the urban high way run off from Ikorodu expressway of Lagos was studied between March to May, 2004.The heavy metals studied include Pb, Cu, Cr, Zn and Cd. The levels of these selected heavy metals were determined using Atomic Absorption Spectrophotometer (M-scientific 200 Model). Trends in the heavy metal from the runoff showed significant variations between the months were values recorded in the month of April showed high values. Statistical analyses showed different mean levels of these heavy metals assessed at the five collecting points. The distribution shows Zn > Pb > Cu > Cr > Cd. Zn recorded the highest concentration levels between (53.4 ± 35.5 - 107.5 ± 80.4 µg/l), while Cd levels (ND - 6.00 µg/L) were the lowest. However, the results obtained falls within the permissible limits of FMENV effluents limits, FHWA and WHO standards of water for domestic use.

Key words: Heavy metals, Onipanu, Obanikoro, palmgroove, road runoff.

INTRODUCTION

Water is an essential resource for living systems, agricultural production, industrial processes and domestic use. However mans' activity towards urbanization (Road and highway construction) and industrialization has chiefly led to the pollution of water by runoff flows. Road runoffs are characterized by mixture of toxicants that are released without prior treatment into the receiving water bodies. Typical pollutants include: suspended solids, heavy metals, hydrocarbons and bacteria of animal origin (Hvitved–Jacobson and Yousef, 1991).

The fate and magnitude of these pollutants found in highway runoff are site-specific and are affected by the volume of traffic, design of the road way, climate and surrounding land use. Roadways with higher average–daily traffic (for instance 30,000 vehicles per day) may produce runoffs with two to five times higher pollutant level than is found in rural highways. Highway runoff pollutants exert significant impacts that could lead to degradation of aesthetic, recreational, biological, physical and chemical qualities of the receiving waters.

According to Maltby et al., (1995) particulate materials tend to be a major constituent in road runoffs, with tendency of accumulation in the sediments of the receiving water bodies.

According to (Ademoroti, 1996a, b) metals with densities greater than 5 gcm^{-3} are referred to as heavy metals. In urban runoffs, metals such as copper, zinc, lead and cadmium have been reported with high level concentration. These heavy metals may have gained access to the runoffs through natural and anthropogenic sources (Duzgoren-Aydin et al., 2006; Florea and Busselberg, 2006). The continuous increase in heavy metal contamination of estuaries and coastal waters is a cause for concern as these metals have the ability to bioaccumulate in tissues of various biotas and may also affect the distribution and density of benthic organisms (Griggs et al., 1977).

Many heavy metals adsorb to particulates and sediments. These settle out and reduce the metals availability for biological uptake (Hung and Hsu, 2004).

The occurrences of elevated levels of heavy metals

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Figure 1. Map showing the sampling site (Ikorodu road in the Lagos metropolis, Nigeria). Source: www.Google maps.com.

especially in the sediments can be a good indication of man induced pollution rather than natural enrichment of the sediment by geological weathering (Davies et al., 1991; Udosen, 1992; Forner and Wittman, 1993). Several studies have reported the impacts of heavy metal (lead and Cadmium). The deleterious impacts include: reduced growth and development, cancer, organ damage in males (sterility), nervous system damage (Yilmaz, 2005; Asuquo et al., 2004; Riba et al., 2003; Ademoroti, 1996a). Vehicular movements contribute significantly to the impact of heavy metals either directly or indirectly. Vehicles part (brake lining) is known to contain copper which provide mechanical strength and assist in heat dissipation. However, wears of these parts occur as a result of abrasion and corrosion processes of tyres, brakes and clutch linings. Thus contribute to the elevated level of heavy metals in run off flows. In this study, the authors seek to assess and document the traffic related pollutant (heavy metals) loadings in runoff waters and the potential environmental impacts using the Ikorodu expressway of Lagos as a case study.

MATERIALS AND METHODS

Study area

Ikorodu road is one of the major roads in the Lagos metropolis Nigeria (Figure 1). The road is usually busy with a traffic volume of about 30,000 vehicles per day. It is a four lane dual carriage way which stretches from Jibowu to Ikorodu town linking other roads in the city (The mainland and island areas of Lagos). The road is of flat topography, impervious in nature and with asphaltic and bituminiuous coatings which accelerate free flow of runoffs through underground ducts and receiving channels down to the lagoon.

Sample collection

Samples were collected between March and May, 2004. Replicate runoff water samples were collected at five different points along Ikorodu road of Lagos. These sampling points were located at Onipanu, Palmgroove, Obanikoro and Anthony points. The fifth is a collecting stream through which runoff flows into the Lagos Lagoon.

Sample preparation

Samples were collected in 2 liter plastic containers and 200 cm^3 reagent bottles properly cleansed with distilled deionized water prior to usage. Collection was carried out by careful immersion of the sample containers deep inside the water and sealing with tight fitting corks and stoppers after collection, in order to avoid air bubbles. Samples were transferred to a refrigerator (4°C) prior to analysis.

Preparation of standards

Instrumental calibration was carried out prior to metal determination by using standard solutions of metal ion prepared from their salts. Commercial analar grade 1000 ppm stock solutions of Pb^{2+}, Zn^{2+}, Cd^{2+}, Cu^{2+}, Cr^{2+} were diluted in 25 cm^3 standard flask and made up to the mark with deionized water to obtain working standard and

Table 1. Distribution of heavy metals in the first runoff samples in week two of March, 2004.

Heavy metal	Onipanu (µg/l)	Palmgroove (µg/l)	Obanikoro (µg/l)	Anthony (µg/l)	Receiving link (µg/l)
Pb	20.0	22.0	11.0	22.0	17.0
Cu	15.0	13.0	11.0	12.0	22.0
Zn	65.0	72.2	67.9	69.7	56.6
Cr	3.0	3.0	3.0	11.0	4.0
Cd	ND	ND	ND	ND	ND

Table 2. Distribution of heavy metals in the second runoff samples in week two of April, 2004.

Heavy metal	Onipanu µg/l	Palmgroove µg/l	Obanikoro µg/l	Anthony µg/l	Receiving link µg/l
Pb	68.0	12.0	74.0	62.0	26.0
Cu	29.0	21.0	48.0	27.0	41.5
Zn	125.4	75.0	200.0	77.9	117.5
Cr	5.0	3.0	16.0	7.0	7.0
Cd	ND	ND	0.6	ND	ND

Table 3. Distribution of heavy metals in the third runoff samples in week two of May, 2004.

Heavy metal	Onipanu µg/l	Palmgroove µg/l	Obanikoro, µg/l	Anthony µg/l	Receiving link µg/l
Pb	55.0	ND	ND	3.0	ND
Cu	26.0	12.0	13.0	37.0	23.5
Zn	48.0	59.0	54.6	12.7	46.1
Cr	1.0	1.0	3.0	3.0	3.0
Cd	ND	ND	ND	ND	ND

solution of 2.0, 3.0 and 4.0 ppm of each metal ion.

Heavy metal determination

The run off water samples were digested using concentrated nitric acid HNO_3 and concentration of Lead (Pb), Zinc (Zn), Cadmium (Cd), copper (Cu) and Chromium (Cr) measured on a M-scientific 200 model atomic absorption spectrophotometer (AAS) (Williams et al., 2007; Essien et al., 2006; Adekoya et al., 2006) at ROTAS SOIL LAB. Ibadan, Nigeria. The essence of the digestion before analysis was to reduce organic matter interference and convert metal to a form that can be analyzed by AAS.

RESULT AND DISCUSSION

The monthly distribution profiles of selected heavy metals in the run off water samples collected at five different points along the Ikorodu road of Lagos are presented in Tables 1 - 3, while their concentration in the three monthly collections are reported as mean and standard deviation and highlighted in Table 4. Trends in heavy metal in urban runoff waters revealed monthly variation in the samples investigated. At 95% confidence interval, the degree of distribution of Zn, Cu, Pb and Cr were signify-cantly different in the runoff samples at the different sampling points, while the distribution of cadmium was not. Zinc and copper were the most predominant in all the runoff samples.

The mean ± standard deviation recorded are 79.5 ± 40.7; 68.8 ± 8.7; 107.5 ± 80.4; 53.4 ± 35.5; 73.4 ± 38.6 µg/L for zinc and 23.3 ± 7.4; 15.3 ± 4.9; 24.0 ± 20.8 ; 25.3 ± 13.8; 29.0 ± 10.9 µg/L for copper . The high level of zinc recorded agrees to previous reports on road run offs that tyre wears resulting from abrasion and friction on impervious surfaces contributes significantly to the increase in the incidence of zinc in highway runoff.

40% detection was observed for lead in runoff samples collected in May 2004 as only 2 samples gave detection values (55.0 and 3.0 µg/l). The low level of lead (Pb) detection could be attributable to reduction in the use of leaded fuel and possibly the diverse nature of road runoffs within this period of assessment. Furthermore, the effect of lead (Pb) to the receiving links (water bodies) cannot be underestimated. This is due to risk posed to life particularly the aquatic organisms which serve as source of food for man (Young and Blevins, 1981). In the runoff samples collected in the month of April, the concentration of the heavy metals were very significant in the order Zn > Pb > Cu >Cr (200 > 74 > 48 > 16 µg/l). This result is of concern particularly when considering

Table 4. Metal concentration (µg/l) reported as mean and standard deviation.

Heavy metal	Onipanu µg/l	Palmgroove µg/l	Obanikoro µg/l	Anthony µg/l	Receiving link µg/l
Pb	47.7 ± 24.8	17.00 ± 2.2	42.5 ± 44.6	29.00 ± 30.1	21.50 ± 6.4
Cu	23.3± 7.4	15.3 ± 4.9	24.0 ± 20.8	25.3 ± 13.8	29.0 ± 10.9
Zn	79.5 ± 40.7	68.8 ± 8.7	107.5 ± 80.4	53.4 ± 35.5	73.4 ± 38.6
Cr	3.0 ± 2.0	2.3 ± 1.2	7.3 ± 9.3	7.0 ± 4.0	4.7 ± 2.1
Cd	ND	ND	ND	ND	ND

the toxic effects to the aquatic ecosystem, although zinc (Zn) is not a human carcinogen but excessive intake through contaminated food chain could lead to vomiting, dehydration, vomiting, abdominal pain, lethargy and dizziness (ATSDR, 1994). The sample collected from Obanikoro sampling point in April showed the presence of cadmium at 0.6 µg/l. In other monthly samples collected, cadmium was not detected in all the runoffs. This low concentration could be due to low level of cadmium in street dust as reported by Perdikaki and Madison (1999). It may also be due to first flush effect when concentrations of runoff are not yet diluted by the rain. The receiving channel showed no significant difference in the concentration of heavy metals when compared to other points where samples are collected. This may be due to runoff flow between other sampling points to the receiving channel (E). Thus the concentration levels of the metals fall almost within the same range as metals from other samples. (3 - 200 µg/l for samples from other points and 3 - 117.5 µg/l for receiving channel). Statistical analyses revealed different mean levels of heavy metals from runoffs in the different sampling points (Onipanu, Palmgroove, Obanikoro, Anthony and Receiving link), the distribution followed the same sequence Zn > Pb > Cu > Cr > Cd.

Generally the average concentration of the metals analyzed in the runoff compares well with results obtained for similar highway runoff carried out in United Kingdom highway. Also the values obtained for these heavy metal falls within the permissible limits of FMENV effluents limits, FHWA and WHO standards of water for domestic use (Clark, 1986).

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