URBAN GEOCHEMISTRY OF LAGOS, NIGERIA

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Abstract

The coastal city of Lagos presents a unique environmental setting, by virtue of its geographical location, its population dynamics and the rising flurry of industrial activities. The City's topography is flat and low-lying, generally below 17 meters. It is the most populous, and most commercially vibrant urban centre in West Africa. Such combination of geographic and demographic factors determine the cycling of pollutants in soil, water and air, as well as amplify the effects of processes that cause rising sea levels, flooding and coastal erosion. The City is affected by multiple and varied sources of pollution such as the burning of fossil fuels, industrial and manufacturing activities, such as the handling of petroleum products, human and industrial waste disposal, vehicular traffic emissions and geogenic dust. The focus of this paper is to re-assess the state of the soil, water and air environments of the City of Lagos, as the media supporting all other components of the total ecosystem; and to look at innovative and proactive ways of clean-up, in assisting municipal authorities formulate more tangible ways for possible revision of existing remedial schemes.

Keywords: *sources of pollution, geochemical cycling, fate, monitoring, clean-up, Lagos, Nigeria*

Introduction

The City of Lagos has a unique environmental character that influences greatly the spatial and temporal complexion of its urban geochemistry. This uniqueness is shaped by its peculiar geographical location (very low elevation), its high population density (number of residents per square kilometer of land) and the flurry of commercial activities. This mix of geoenvironmental characteristics make perturbations in the flux of chemical and biological pollutants from myriads of sources an apparently intractable issue. Diffusion of potentially harmful elements (PHEs) and petroleum hydrocarbons into the soil, water and air environment produces a profound influence on human health and ecosystem integrity.

The enormity of geochemical fluxes and the human manipulation of the landscape change the nature of transport and retention processes of metals, and give this City a geochemical character different from other megacities around the continent. A huge campaign for an organized effort in the study of the geochemistry of Lagos soils has recently been mounted (e.g., Abimbola and Olatungie, 2011; Alani et al., 2013), probably as a result of the growing realization that many environmental illnesses in and around the City can be explained by exposure to loads of toxic metals and organics dispersed into soils, hydrological system and atmosphere, largely from vehicular traffic emissions, oil spills, unregulated waste disposal practices and pervasive geogenic dust.

The scenario of pollution in Lagos metropolis continues to this day. An overview and analysis of the present state of pollution is presented and an illustration given on how local environmental quality problems might be more efficiently and economically tackled. By performing a critical review of the situation and trends, and by casting light on the shadows, an attempt is made to expose the dimensions of the problems. Alternatives for strengthening regulatory measures and improved monitoring of legislative imperatives are put forward.

Contamination of Lagos soils

It is now well established that roadside soils in Lagos metropolis is moderately to severely polluted with PHEs and persistent organic pollutants (POPs), including petroleum hydrocarbons. Major sources are vehicular traffic emissions and improper handling of refined petroleum products (e.g., Adeniyi and Afolabi, 2002; Adeniyi and Owoade, 2010; Abimbola and Olatungie, 2011; Olukanni and Adeoye, 2012; Olukanni and Adebiyi, 2012; Alani et al, 2013). According to Olukanni and Adeoye (2012), despite the change in petrol specification by the Standards Organization of Nigeria (SON) on zero lead, and the input of the Department of Petroleum Resources (DPR) to ensure that all petrol coming into Nigeria should be unleaded, since June 2002, the situation of increased pollution from mobile transportation sources is on the increase in per capita vehicle ownership.

Operations at Nigeria's massive petroleum industry often involve the distribution of petroleum products to neighbouring storage facilities through Lagos. This often leads to accidental pollution, such as chemical spills due to road accidents or from leakage from holding tanks, reservoirs, or pipelines. Several authors have shown recently how elevated levels of PHEs (such as Cd, Cu and Ni) in Lagos soils are transmitted into food crops grown in the vicinity of industrial and residential areas of Lagos City, and thence into food chains, where they are disposed to cause an array of undesirable environmental health conditions in Lagosians (see e.g., Yusuf et al., 2003).

Hydrogeochemical impacts

The problem of contamination of the groundwater resources and aquifers underlying the Lagos metropolis has long been recognised. Back in 1987, Longe et al. used data obtained from well-logs, pumping tests, well-production rates and water quality testing, to perform a comprehensive evaluation of the groundwater resource of this megacity (Lagos).

Again in 2011, Longe investigated the hydraulic properties of the aquifers located in the coastal plain sands of Lagos, and showed by step-drawdown pumping tests, that well losses constitute a significant component of drawdown in the pumped wells. More recently Oladapo et al. (2014) studied the saline water intrusion phenomenon in the Lagos Municipality, employing geophysical techniques, and highlighted the depreciation in quality of the water resource due to over-pumping (at higher rate than the natural recharge) and slow sea level rise.

Adesemoye et al. (2006) studied microbial content of wastewater in two abattoirs in Lagos, and the impact on microbial population of receiving soil. High microbial load in abattoir wastewater with negative effects on microbial population in soil was noted in this study, further confirming the need to treat wastewater rather than discharging it to the environment. The unregulated disposal of solid waste is another major source of pollution of the Lagos water supply network (e.g., see Oladapo et al., 2012). One of the major dumpsites in Lagos, the Olusosun “landfill” is the largest dump in Africa, and one of the largest in the world. The site receives up to 10,000 tonnes of rubbish each day (Longe and Enekwechi, 2007).

Figure 1. Satellite image of the Olusosun, the largest dumpsite in Lagos, Nigeria.
Credit: The Gaurdian, All Africa. Source: http://www.businessinsider.com/worlds-largest-dumps-2011-2?op=1 (accessed 20.09.14).

In 2013, Sanusi performed an assessment of the groundwater quality at Olusosun, to determine interactions between the landfill wastes and the groundwater, and the potential migration of pollutants into the neighbouring communities. As expected, the results indicated that the Olusosun landfill has impaired groundwater quality, thereby, posing environmental and human health concerns to the neighbouring communities of Oregun, Ketu and Ojota.

Ambient Air quality

Air quality issues, such as ground-level O_3, particulate matter (PM), the release of other air contaminants and acid rain, largely occur in the lowest part of the Lagos atmosphere - which holds the air that is inhaled.

Some monitoring of geogenic sources of air pollution in Lagos, e.g., roadside dust containing pathogens and indoor radon concentrations in ambient air, have been reported (see e.g., Hunter et al., 2009; Sundal et al., 2009). Advection of Sahara particulate matter (Harmattan dust) during the months of December and January, and atmospheric radioactivity from Niger, add significantly to the particulate load. But few studies have attempted correlations of atmospheric pollutant factors with respiratory disorders or other conditions linked to inhalation of mineral dusts.

Most of the studies on air pollution in Lagos have used model and simulated approaches, and have attributed the bulk of noxious emissions to heavy vehicular traffic and widespread use of generators for electricity to power machinery and other electrical equipment. Itua (2007) illustrated the mode of dispersion of the major components of the atmospheric pollution load, notably the gases NO_2, CO and VOC, which are generated by roadside vehicles, and contribute to the greenhouse effect. The amount of PM, comprising mainly smoke, dust, fog and mist may also be significant. Air sampling in Lagos from 2001-2005 led to an estimated annual mean ambient air particulate concentration of 122μg/m^3, about 500 percent higher than the 20μg/m^3 threshold established by WHO (Taiwo, 2005).

Figure 2. Vehicular traffic density in central Lagos.
Source: http://www.21stcentech.com/wp-content/uploads/2012/03/lagos-air-pollution.jpg (accessed 01.02.15).

Other studies have provided top-down emissions estimates for Lagos City. For example, Hopkins et al., (2009) completed a boundary layer circumnavigation of Lagos using the FAAM BAe146 aircraft as part of the African Monsoon Multidisciplinary (AMMA) project. Their extrapolations, made within the context of an inferred boundary layer gave annual emissions for CO, NO_x, and volatile organic carbons (VOCs) of 1.44 Tg yr^{-1}, 0.03 Tg yr^{-1} and 0.37 Tg yr^{-1} respectively, with uncertainties of $^{+250}/_{-60}$% (Hopkins et al., 2009). These inferred emissions are consistent with bottom-up estimates for other developing megacities and were attributed to the evaporation of fuels, mobile combustion and natural gas emissions.

Olowoporoku et al. (2012) provide an overview of the emergent public health risks attributable to air pollution in Lagos and solutions to reduce them. These authors argue that an understanding of the scale and spatial variation of air pollution is not sufficient for reducing the risks posed to public health.

Urban Geochemical Databases

Although soil is recognised to be critically important, our knowledge of the concentration of naturally-occurring elements in soil is limited, especially for many sub-Saharan Africa landscapes. At present few complete regional geochemical databases exist in African countries.

The globally integrated Africa Soil Information Service (AfSIS) project (AfSIS, 2014) was established to address the need for accurate up-to-date and spatially referenced soil information to support agriculture in Africa. Work on the construction of a formal geochemical database for Nigeria started off in 2008, with some critical cells including those for Lagos, already completed (Lapworth et al., 2012)**.**

However, for urban geochemistry studies to succeed in Africa, an obvious first step would be the preparation of high-quality geochemical databases for entire regions, preferably in conformity with guidelines laid down in the "Global Geochemical Baselines Initiative" (Darnley et al., 1995). Such databases would be at their most useful when applied to urban soils where large-scale anthropogenic influences have produced extreme departures of metal contents from expected background values. They will also facilitate the modelling of environmental systems linked to issues of formulating environmental management and legislative control mechanisms.

Legislation

Environmental legislation in Nigeria is quite extensive, though enforcement at State level remains weak. For example, there is adequate legislation and regulation on land use practices and environmental audits (Aluko, 2012; ELRI, 2011; Ladan, 2012), but no specific requirements have been found for applicants who propose developments in identified management areas that are considered hazardous.

The basic laws governing the preservation of environmental integrity of urban conurbations in Nigeria are enshrined in the Federal Environmental Protection Agency (FEPA) Act of 1988, amended by Act No. 59 of 1992 (Frynas, 2000). A recent and important addition to this Act is the National Environmental Standards and Regulations Enforcement Agency (Establishment) Act (NESREA Act), which came into force in 2007. The Act establishes NESREA as Nigeria's lead environmental protection Agency, with mandate that includes protection of the environmental integrity of urban agglomerations in the country.

Advocating a more stringent legislative framework for the control and regulation of vehicular and industrial emissions (e.g., use of lead-free gasoline) and determination of a practical set of guidelines, will no doubt go a long way towards combating air pollution problems in Africa's megacities.

Conclusion

The enormity of geochemical fluxes and the human manipulation of the Lagos landscape change the nature of transport and retention processes of metals, and give this City a geochemical character different from other megacities around the continent. Ajmone-Marsan and Biasioli (2010) have drawn attention to the relevance of the urban soil system, and the importance of harmonizing sampling and analytical methods in collecting urban geochemical data for formulation of regulatory procedures, and for providing environmental scientists and city planners with essential database. Bioremediation using microorganisms and plants is recommended for soil clean-up.

The rapid increase in the use of vehicles for day to day transportation in Lagos, coupled with an apparent lack of emission standards has aroused a great deal of concern among environmentalists. Well planned transportation infrastructure can reduce considerably overall per capita carbon emissions through, for example collective transport as in the case of New York City, where per capita emissions are 30 percent less than in the United States as a whole (Dodman, 2009). Implementation of stricter standards imposed on the rates of emissions from different kinds of vehicles, the use of alternative or cleaner fuels like ethanol, improved technology, and transportation regulations should be considered viable measures. Emission inventories are an essential element of air quality management programmes. They must be meticulously kept, as they provide a basis for regulatory programmes, dispersion modeling, emission trends analysis and many other programme activities.

Spies et al. (2010) have developed a tool referred to as 'SWM-GHG Calculator' (Tool for Calculating GHG Emissions in Solid Waste Management") that could be used to calculate GHG emissions in solid waste management with applications to low- and middle-level countries. Proper management of solid and liquid waste will help protect our water supplies from pollution. It is possible to recommend that a combination of all viable technologies, *viz*., recycling, good management of landfills engendering geological controls, composting and biogas production, must be judiciously applied in order to reduce greenhouse gas emissions and bring about emission reduction (certified emission reductions (CERs); verified emission reductions (VERs), and sustainability certificates.

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