Assessing Pb levels and pollution risks in Lagos lagoon core sediments

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Abstract. Lagos lagoon is one of the most impacted aquatic ecosystems in Nigeria mainly attributed to anthropogenic activities. The focus of this study was to evaluate the vertical distribution of lead (Pb) in twenty-five (25) core sediment samples (CSS) collected from the lagoon. The metal burden in CSS was assessed using the contamination factor (Cf) and degree of contamination (Cdeg) pollution indexes. The concentrations of Pb in core sediments ranged from 0.18±0.01 to 3.08±0.57 mg/kg, and were significantly below established sediment quality guidelines (SQGs). The results from calculated indexes show no potential adverse effects or environmental risk is possible as a result of Pb concentration. However, a continuous monitoring of sediment quality in the lagoonal ecosystem is recommended for the study area.

Keywords: Core sediment, lead pollution, toxic metal, pollution indexes, risk assessment

1. Introduction
Sediments are essential storehouses of pollutants [1-4]. Contemporary studies have shown that pollutants including heavy metals in sediment cores have become a global problem and pose considerable risks to humans and aquatic environments [5]. In recent years, several studies involving major and trace elements in core sediments have produced invaluable approach for understanding the impact of natural and human-mediated processes associated with metal pollution records and depositional history in aquatic ecosystems [6-8]. It provides depth profile information for various heavy metals in surficial sediments (recent deposition) and down-core sediments (pre-industrial deposition) in fresh and shelf water systems [6,9].

Lead (Pb) pollution in core sediments poses a serious environmental concern as a result of their substantial toxic effects, non-biodegradability, and bioaccumulation potential. The assessment of Pb pollution and the attendant environmental risks can be evaluated through the use of consensus-based sediment quality guidelines and indices. Sediments could be valuable indices for monitoring contaminants in aquatic environment [10,11]. The presence of Pb in fish is a serious health challenge to human consumers, and Pb is commonly available in aquatic environments from anthropogenic sources [12]. Pb at high concentrations could be toxic and hazardous especially when accumulated in core sediments may be exceedingly detrimental to human and aquatic environments. Sediment quality guidelines and baseline reference values are generally used in environmental risk assessments to evaluate metal pollution in aquatic environments. Numerous statistical and experimental indices have been established as answer to ecological concerns and as valued pollution indicators for monitoring.
aquatic environments. The objectives of the present study are to determine the concentrations of Pb in core sediments of Lagos lagoon, and to establish the degree of contamination by Pb using two pollution indexes.

2. Materials and method

2.1 Study area

This study was undertaken in the cosmopolitan segment of Lagos lagoon area. Lagos lagoon has an area of about 208 km2 and is located between latitude 6°26'N and 6°38'N longitude 3°23'E and 3°43'E. The lagoon is exposed to contamination of anthropogenic activities including urban development, fishing activities, petrochemical industry, and shipping and tanker operations. The sampling site has an elevation of 4.8 m.

2.2 Sample collection and analysis

Core sediment samples were collected on January 26, 2018 using a sediment corer along Lagos lagoon at a sampling point of about 500 m distance away from the shore and designated as core A (06°28'07.8"N, 003°22'16.6"E). The sediment core was 50 cm in length and 3.5 cm in diameter. In the field, the sediment core was carefully subsampled at 2 cm intervals giving a total of twenty-five (25) subsamples. The samples were stored and transported from site to laboratory at a temperature of about -4°C. Samples were stored in a labeled white transparent plastic air tight container, transferred to the laboratory and kept frozen until analyzed. In the laboratory, 0.5 g of air-dried sediment samples from each subsample were digested using a mix of perchloric acid, nitric acid and sulphuric acid in the fume-hood. The extracts were later analyzed using Microwave Plasma Atomic Emission Spectrometry (4200 MP-AES).

2.3 Risk assessment

In this study, the risk assessment of Pb pollution was carried out using the following indicators; contamination factor and degree of contamination.

2.3.1 Contamination factor, Cf

The contamination factor (\(C_f\)) is described as the ratio of associated concentration of contaminants in the environment to the background value:

\[
C_f = \frac{C_m}{C_{bkg}}
\]

where \(C_m\) is the concentration of the heavy metal and \(C_{bkg}\) is the background concentration (average shale value). The contamination levels were categorized as follows: \(C_f<1\) indicates low contamination; \(1<C_f<3\) is moderate contamination; \(3<C_f<6\) is considerable contamination; and \(C_f>6\) is very high contamination.

2.3.2 Degree of contamination, \(C_{deg}\)

The degree of contamination was introduced by [13], and was originally a method to calculate an overall pollution factor, based on some metals and an organic contaminant. According to [14], the \(C_{deg}\) is computed using the following formula:

\[
C_{deg} = \frac{\sum_{i=1}^{n} C_f}{n}
\]

Håkanson [13] recommended the classification: \(C_{deg}>24\) is a high contamination degree, showing severe anthropogenic pollution; \(12<C_{deg}<24\) is a considerable contamination degree; \(6<C_{deg}<12\) is a moderate contamination degree and \(C_{deg}<6\) shows a low contamination degree.

3. Results and discussion
3.1 Pb vertical distribution

In this study, Pb concentration in twenty-five (25) core sediments samples from Lagos Lagoon is presented in Fig. 1. Pb concentrations varies at different depth profiles. However, Pb recorded the highest concentration of 3.08±0.57 mg/kg at the 10 cm depth. The concentration of Pb also indicated an increasing trend from top-core 2 cm to 10 cm. However, the down-core 22 cm had the lowest concentration of 0.18±0.01 mg/kg. The concentration of Pb across the depths was lower than the adopted background shale value, and this could pose minimal effects to sediment-dwellers. However, Pb contributions from anthropogenic activities require routine monitoring.

![Figure 1: Vertical variation of Pb levels in core sediment samples of Lagos lagoon](image)

3.2 Contamination factor and degree of contamination

The results of the calculated contamination factor and degree of contamination of Pb are presented in this section. The $C_f$ for Pb ranged from 0.02 to 0.15 with the highest value indicating a low contamination ($C_f<1$) of sediment due to Pb. The levels of Pb were relatively similar to those reported by other researchers (Caeiro et al., 2005). The degree of contamination in this report is the aggregate of $C_f$ for Pb, and was calculated to be 1.31. The $C_{deg}$ value of Pb shows a low contamination degree because $C_{deg}<6$.

Conclusion

The vertical distribution of Pb has been assessed in the core sediment samples of Lagos lagoon. The sediment contamination indices including contamination factor and degree of contamination were used to evaluate the pollution level of Pb concentrations in collected core sediments. The results of contamination factor ($C_f$) and degree of contamination ($C_{deg}$) values of Pb show low polluted core sediments. Continuous monitoring and assessment of sediment pollution status is advocated.

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