Geospatial distribution of heavy metal contamination in Ewekoro Limestone, SW Nigeria

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Abstract. Limestone exploration has numerous advantage to the nation’s economy. However, major anthropogenic activities such as mining of such mineral deposits causes environmental contamination due to heavy metals pollution. The presence of heavy metals such as lead, cadmium, mercury and arsenic can interfere with the biochemical pathways by interaction with enzymes and proteins. They equally have the capacity to alter the DNA repair mechanism and act as the inducers of carcinogenesis. The focus of the research is therefore to detect the extent of heavy metals contaminations within the sampled Ewekoro limestone, southwestern Nigeria and to ascertain the risks they posed to the quarry workers, miners and the people residing in the study area.

Keywords: Limestone deposit, Geospatial distribution, Heavy metals, Contamination, Environmental pollution studies.

1. Introduction

Presently, heavy metal poisoning has become a global concern as a result surface and subsoil contaminations which most times ultimately become source of pollution to the environment and groundwater as the heavy metals percolate and infiltrate into the groundwater as rain fall. Toxicity of these heavy metals threatens the health of the flora and fauna within the ecosystem [1-3]. Heavy metals refers to those metallic elements with high density compared to water containing metals or metalloids, such as arsenic (As), chromium (Cr), copper (Cu), manganese (Mn), nickel (Ni), tin (Sn), lead (Pb), mercury (Hg), zinc (Zn), cobalt (Co), iron (Fe), magnesium (Mg), molybdenum (Mo) and selenium (Se). Some of these elements act as essential micro-nutrients as essential micro-nutrients required for most physico-chemical functions in plants and their deficiency cause diseases but become toxic when their concentrations are high [4]. High concentrations of these heavy metals in nature become detrimental on biological systems by inducing multiple organ damage and they do not undergo biodegradation. Few of these elements like lead, cadmium, arsenic, and mercury have no biological importance or valuable use and have been recognized to be extremely toxic [5-6].
Numerous studies suggested that there are two main sources of heavy metals polluting the environment, and they are: natural (geogenic) and anthropogenic sources. Geogenic sources involve the natural occurrence of heavy metals throughout the earth crust via the processes such as weathering, soil erosion and volcanic eruptions[7]. Anthropogenic sources of heavy metal contamination include industrial activities like mineral mining, exploration and smelting, industrial production, pharmaceutical effluents, domestic and agricultural usability of metals and metal-containing compounds [8]. Quarrying of limestone deposits with high heavy metals concentration has several diverse effects on the environment. Groundwater pollution if rain water within the quarry region percolate into the subsoil, thereby contaminating the subsurface water body. Also, if there is any river around the quarry, limestone pebbles may roll into the river thereby contaminating the water. Air pollution of the heavy metals may result from limestone particles taking the form of dusts and being transmitted from the quarrying site to other parts of the area. Heavy metals when found in limestone deposit could serve as a threat to the health of the miners, it could be cancerous depending on the concentration of these metals in the limestone. Elevated concentrations of arsenic in limestone has negative impacts on plants and human. It can induce damage to the brain cells, liver, kidney and other vital organs and also causes cancer [9-10]. Lead from dust particles or aerosols is highly toxic. It is a systemic toxicant that affects multiple body systems such as neurologic, hematologic, gastrointestinal, reproductive, cardiovascular and renal systems[11]. Elemental mercury is a toxicant that is widely distributed in the environment and are capable of inducing several alterations in body tissues and causes adverse health effects [12]. Absorbed mercury from environmental exposure gets accumulated in kidney, neurological tissues and liver; and their effects include neurotoxicity, nephrotoxicity and gastrointestinal [13]. The thrust of this study is environmental pollution studies [14-18]which involves the quantitative analyses of the level of the concentration of heavy metals like arsenic, mercury, cadmium, cobalt, chromium, nickel, lead and zinc in some collected Ewekoro limestone samples using a microwave atomic absorption spectrometer. Also the geospatial distributions of these heavy metals are carried out and their potential health threats to the miners and workers within the quarry site and the entire residents within the study area are discussed.

2. Methodology

2.1 Study Area

The area of study is a limestone quarry site situated between the easting of 3°05’ to 3°15’ and northing 6°40’ to 6°55’ located in Ewekoro L.G.A, Ogun state, SW Nigeria. Ogun state is bounded to the North, South, West and East by Oyo state, Lagos state, Benin republic and Ondo state. Figure 1 shows that the area lies geologically within the Eastern section of the Dahomey basin with east-westward trend sediments deposition and six lithostratigraphic units comprising Benin, Ilaro, Oshosun, Akinbo, Ewekoro and Abeokuta Formations from youngest to the oldest geological formation. Ewekoro Formation is known to be a Paleocene shallow marine deposit of non-crystalline and non-fossiliferous limestone strata.

2.2 Samples Collections and Preparation

Twenty (20) limestone samples along with their GPS coordinates were obtained from rock outcrops within the limestone quarry site. The samples were sieved with the intention of removing pebbles and other irrelevant materials that could cause error in the final output of the analysis. The samples were prepared by drying them properly in order to ensure that they are air tight. They were then ground and sieved.2g of limestone sample was put in a beaker with addition of both concentrated HNO3 (2.5 ml) and concentrated HCl (10 ml). The beaker was heated using hot plate for about 15 minutes for optimal digestion. Whatman No. 41 filter paper was used to filter the digestate from the heated into a 100 ml volumetric flask. The digested solution was later diluted with 100 ml volume of distilled water.
and then analysed using a Microwave Atomic Absorption Spectrometer. Nine heavy metals elements concentration levels were measured within the twenty limestone samples.

3. Results and Discussion

The concentration levels of arsenic, mercury, vanadium and lead were measured in the limestone samples collected from different parts of the study area. The results are presented in charts (Figure 2) and the geospatial distributions of these heavy metals are shown in Figure 3. It is observed that the concentration of arsenic ranges 0.002 to 1.103 mg/kg with mean 0.291 mg/kg. Mercury concentration level within the collected samples ranges 0.02 to 0.32 mg/kg with mean 0.062 mg/kg. The concentration of cadmium ranges 0.014 to 1.897 mg/kg with mean 0.595 mg/kg. The concentration of cobalt ranges 0.004 to 0.052 mg/kg with mean 0.027 mg/kg. The concentration of chromium ranges 0.002 to 1.141 mg/kg with mean 0.225 mg/kg. The concentration of nickel ranges from 0.145 to 0.521 mg/kg with mean 0.296 mg/kg. The concentration of lead ranges from 0.01 to 1.930 mg/kg with mean 0.406 mg/kg. The concentration of vanadium ranges from 0.015 to 1.014 mg/kg with mean 0.243 mg/kg. The concentration of zinc ranges from 0.026 to 2.553 mg/kg with mean 0.535 mg/kg. It is imperative to compare these concentration levels with standard threshold limits to infer if the exploration of the Ewekoro limestone is safe for environment.

Figure 1: Geology map of the eastern Dahomey basin with the red arrow showing the study area.
Figure 2: Charts showing the representative heavy metals concentration in the study area.
Figure 3: Geospatial distribution of heavy metals composition of the limestone in the study area.
4. Conclusions
Geochemical analysis and geospatial distribution evaluation of heavy metals composition of the EwekoroFormation limestone were carried out. The analyzed elemental constituents were mercury (Hg), zinc (Zn), cadmium (Cd), nickel (Ni), chromium (Cr), lead (Pb), vanadium (V), cobalt (Co) and arsenic (As). Their mean concentration levels were 0.291 mg/kg, 0.116 mg/kg, 0.595 mg/kg, 0.027 mg/kg, 0.225 mg/kg, 0.296 mg/kg, 0.414 mg/kg, 0.243 mg/kg and 0.535 mg/kg respectively. The estimated concentration levels of the heavy metals were compared with the standard threshold limits and their threats to life ascertained. It is recommended that geogenic radioactive contents of the limestone should equally be evaluated.

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