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Environmental Effects of Sand and Gravel Mining on Land and Soil in Luku, Minna, Niger State, North Central Nigeria

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Abstract The increase in the demand for sand and gravel for construction and other purposes such as flood control has placed immense pressure on the environment where sand and gravel resources occur. This study was carried out to determine the environmental effects of sand and gravel mining in Luku, North central Nigeria, using field observations and laboratory analysis of soil samples. Field work was carried out in the area to determine the physical environmental effects of mining while soil samples were analysed at the National Geo-science Research Laboratory (NGRL) of Nigerian Geological Survey Agency (NGSA), Kaduna for trace elements using X-Ray Fluorescence (XRF) method. Result of the field observations shows that destruction of landscape, reduction of farm and grazing land, collapsing river banks, deforestation and water pollution are the environmental effects that result due to sand and gravel mining in the area. Result of the chemical analysis shows that average concentrations of Pb, As, Cu, Ni, Cd, Hg, Ag and Zr are 47.8, 4.17, 50.9, 32.7, 2.48, 0.1, 0.8 and 496.1ppm respectively. These concentrations are higher than the average standard concentrations of these elements found in the upper continental crust. These higher concentrations may have very negative effects on plants and animals in the area and cause diseases such as brain and kidney damage, lung irritation, cardiac abnormality and event death to plants and animals.

Keywords: *sand and gravel, Luku, physical environment, environmental effects, concentrations, deforestation*

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1. Introduction

Sand and gravel mining refers to the process of removing sand or gravel from a place of its occurrence [1]. These materials occur in a variety of natural settings and are commonly used in the construction industries worldwide. Sand and gravel occur on land, oceans, rivers, streams, flood plains or hills [2]. An increase in demand for sand and gravel for construction purposes has placed immense pressure on sand and gravel resources. Therefore, the extraction of these two important construction aggregates is bound to have considerable negative effect on the place where they occur. These aggregates are also mined for other purposes such as navigation purposes, agricultural drainage, flood control and channel stability but still remains the major material in the construction industries.

Rivers and their floodplains are an economical source of sand and gravel. Although these aggregates are of paramount importance, previous studies [1,2,3] have shown that in-stream mining of these aggregates can reduce water quality as well as degrade the channel bed and banks. The mining of these aggregates on the floodplain can affect the water table and alter the land-use for agricultural purposes [1]. Rivers flood and shift their courses from time to time, resulting in natural cycles of erosion and deposition of sand and gravel. The extraction of sand and gravel from rivers, streams, floodplains and channels conflict with the functionality of river ecosystems. Some of the disturbance is from the mining methods and machineries used. The most common environmental impact is the alteration of land use, most likely from underdeveloped or natural land to excavations in the ground [1]. Social pressures like population growth can also cause the environmental impacts of these aggregate mining.

Sand and gravel mining has been one of the serious environmental problems around the globe in recent years. Much work has been carried out to access the environmental impacts of sand and gravel in Nzhelele Valley, Limpopo Province, South Africa [4], where there is an increase in demand for sand and gravel for construction purposes. The extraction of sand and gravel from river, stream terraces, floodplain and channels, conflicted with other resources such as fisheries, recreational functions and with the stability of the river channels. Using field observation and environmental impact assessment guidelines, they identified a host of environmental impacts along Nzhelele valley. These impacts ranged from collapsing river banks, habitat destruction, flood plain ponding, landscape destruction, dust, noise, to sedimentation. Their work has shown that there is significant environmental degradation in Nzhelele valley as a result of unregulated sand and gravel mining. These negative effects had disturbed the balance in nature and this had multiplier effects on the ecosystem. They therefore recommended that the government develops and implements policies and regulations designed to protect the environment around sand and gravel mining areas.

Also [5], assessed the sociological and ecological impacts of sand and gravel mining when he noticed that commercial gravel extraction to supply aggregate to the construction industry in the Northern Region of Ghana particularly the East Gonja District and the Gunnarsholt area of Iceland, had been on the increase in recent years. Perceived sociological and ecological impacts in the two study areas varied but some appeared common to both. The common impacts shown in the results obtained from his work were loss of farm or grazing lands, formation of pits with water stored in them, enhancement of erosion and loss of vegetation, destruction of landscape, generation of conflicts, loss of biodiversity and dust pollution. Other impacts of mining peculiar to EGD were abandoned mine pits serving as sources of breeding grounds for the spread of diseases, loss of economically important trees which causes unemployment among women folk, and the pollution of underground water.

Locally, [6] studied the effects of sand mining activities of rural people on agricultural land in Agraian communities of Ogun state in Nigeria. His work revealed that mining of sand and gravel on agricultural land is one of the alternative livelihood activities of the rural people in Nigeria and is now becoming an environmental issue. He equally noticed that there is increase in demand for sand for construction and other purpose as communities grow because the construction at present requires less wood and more concrete, which sprout a demand for low-cost sand. Mining of sand on farms and fallow agricultural land is becoming common and this is having noticeable impacts on the soil structure, vegetation and local wildlife in the rural areas. He noticed that sand mining is widespread, highly unregulated, uncontrolled and is being carried out at an alarming rate. The gravity of the situation beyond the affected communities and the region at large is enormous and poses a threat not only to the environment but also to food security. Although sand mining contributes to the construction of buildings and development, its negative effects include the permanent loss of sand in areas, as well as major habitat destruction. Sand mining is regulated by law in many places, but is still often done illegally.

In New Mexico [7] carried out the Environmental Impacts of Aggregate and Stone Mining. The results of his study showed that the primary environmental impacts from aggregate and stone mining in New Mexico are degraded air quality and associated health effects, resulting from airborne emissions from both the stack and the disturbed areas at these mines. Because the economics of construction materials depend heavily on the proximity of the mine to the point of use, aggregate and stone mines are found in the highest concentrations in urban areas where most home and office construction and general highway construction occurs. However, these mines are located in every states of the county and many of the largest of the mines producing road construction materials are situated immediately adjacent to highways in order to reduce haul costs. Consequently, the majority of both active and inactive sand and gravel mines are located along interstate highways or major state and county roads.

Luku is located in North Central Nigeria and sand and gravel mining is currently taking place there because the place is a very attractive source for these materials. The area is easily accessible and the materials are easy and cheap to extract by the miners. Mining of these materials in the area is being carried out without any attention given to the negative environmental impacts associated with the activities. This work therefore aims at studying the environmental effects of sand and gravel mining on land and soils in Luku using field observations and laboratory analyses of soil samples. The work also looks at the possible health issues that may result due to high concentration of trace elements in the soils of the area.

2. Materials and Methods

2.1. Field Work

This work follows a qualitative approach in assessing the environmental impact of sand and gravel mining in Luku, North central Nigeria. Investigations were carried out via field mapping and collection of samples. Outcrops were observed and described based on their colour, texture, structural element, mineralogy, mode of occurrence and field relationship. On the field, data were obtained using a global positioning system (GPS) which was used to capture coordinates for the location of mining activities in the area. A camera was used to obtain photographic impressions because of their significant importance in this project. Field observations were made in other to note the existing physical impacts of sand and gravel mining in the area. A shovel was used to collect soil samples from different locations using the random sampling method, from both mined and unmined locations. The soil samples were used to analysed for trace elements concentrations in the area.

2.2. Laboratory Work

2.2.1. Sample Preparation

A total of ten (10) samples were collected from the field for chemical analysis. Samples were taken to the laboratory and air dried for about 72 hours in order to remove the moisture content in them. Each dried sample was crushed or pulverized using a Retch PM 200 or 400 grinding ball mill to a fine powder of 75µm size in other to obtain homogeneity of samples. 75g each of the crushed samples was weighed using an electric weighing balance and put into a polyethene bag and properly labeled for easy identification. The samples were then ready for analysis to determine the trace elements and their concentrations. The sample preparation was done in the laboratory of Geology Department, Federal University of Technology, Minna, Nigeria.

2.2.2. Laboratory Analysis

The powdered samples were analysed for Trace elements using X-Ray Fluorescence (XRF) machine, model: PANalytical, at the National Geo-science Research Laboratory (NGRL), of Nigerian Geological Survey Agency (NGSA), Kaduna. The software used for the analysis was Millipal 4. In this method, about 10g of each the eleven prepared samples was weighed into the sample cup of the X-Ray Fluorescence machine and analysed according to the method described by [8]. The mean concentration of each element in the samples was compared with [9,10] average concentration of elements in upper continental crust. Values that correspond or fall below the expected limit were accepted as safe while values above the limits indicate very high concentrations of such elements in the soil which can cause serious environmental problems to plants and animals including man.

3. Results and Disscussion

3.1. Geology of the Area

The project area is a part of the Minna – Kusheriki schist belt. Geological mapping reveals that the area is composed of Schists intruded by granitic rocks (Figure 1). The Schists are generally dipping in a North-West direction. Granitic rocks outcrop mostly at the Southern part of the area covering about 15% of the total area while schists cover the remaining part of the area. The schists in the area range from medium to coarse grained and consist of quartz, mica and feldspar. Structural features on the schist include joint and foliation which result into schistocity. The granite in the area are intrusive to the schists and are highly jointed. These rocks have been highly weathered resulting in a lot of sand and gravel in river channels, banks and on land.

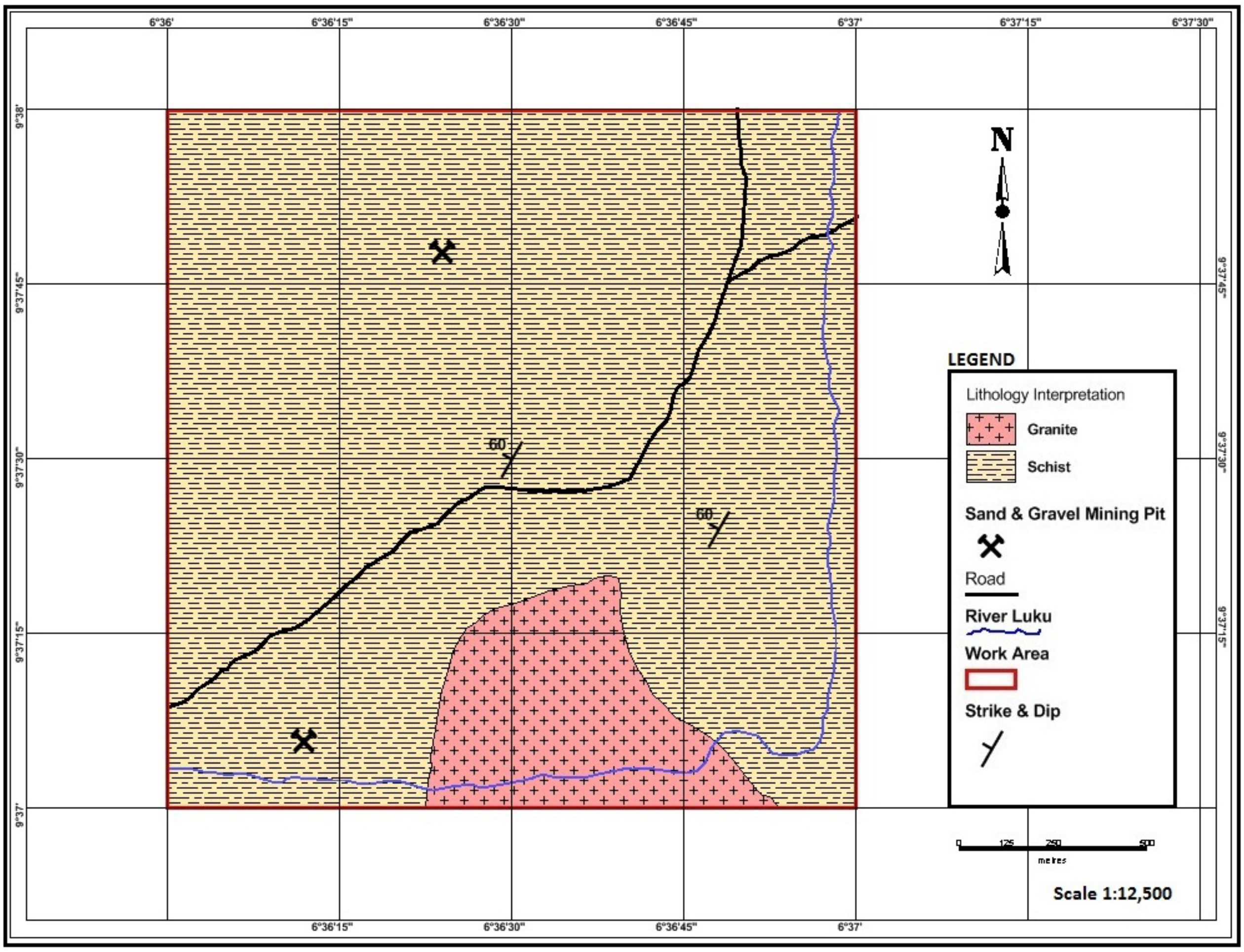

Figure 1. Geological Map of the Study Area

3.2. Field Observations

The study area is currently experiencing sand and gravel mining in considerable quantities and this has resulted in various physical environmental impacts which were observed during field studies. These impacts include:

1. Reduction of farm and grazing lands.

Results from field observation showed that one of the physical effects of sand and gravel mining in Luku is the reduction of farmlands and grazing lands. Farming and animal rearing is one of the activities taking place in the area but sand and gravel mining has taken up most of the productive land meant for these activities. This is because for sand and gravel to be extracted, vegetation is destroyed and this vegetation serves as food for their cattle. This then denies both animals and inhabitants in the area their means of livelihood (Figure 2). In East Gonja District in Ghana where agriculture is the predominant economic activity in the area, [5], reported that gravel mining has not only denied the people in the area their means of livelihood but also to those who practiced agriculture as a way of life, infringed on their cultural heritage.

Figure 2. Loss of Vegetation due to sand and gravel mining. This leads to reduction in farming and grazing grounds in the study area

2. Destruction of landscape.

Landscape destruction, is one of the significant effects of mining in the area. The original landscape has been destroyed and altered as a result of excavated pits and trenches, leaving behind unpleasant sights which as well render the land unsuitable for any productive purpose (Figure 3). During the raining season these pits collect and store stagnant water and as such, serve as breeding ground for pests such as mosquitoes and other water borne insects which in turn can affect the health of the people living in and around the area.

Figure 3. Pits formed from sand and gravel mining resulting in the destruction of the original landscape of the area.

Figure 4. Collapse of river bank due to sand and gravel mining in Luku

3. Collapse of river bank.

There is collapse of river banks in the area due to sand and gravel mining (Figure 4a and Figure 4b). The extraction of sand and gravel around and within the river makes the banks of the river weaker and gradually collapses. This does not only leads to filling of the river channel with sediments but gives room for the water in the river to flow out resulting in erosion which washes away the soil.

4. Deforestation.

Mining of sand and gravel in the study area resulted in destruction of vegetation thereby destroying the natural habitats of some animals (Figure 5). Some very important plant species are also destroyed and the soil is exposed to erosion.

Figure 5. Destruction of vegetation due to sand and gravel mining leading to lost of natural habitats of some animals and some plants species

5. Water pollution

Sediments from mines running off into river and wetlands are significant source of water pollution. Both surface and ground water quality are been affected through contamination with suspended and dissolved materials. In-stream mining of sand, gravel and gold in the area has led to the re-suspension of sediments in the water causing the brownish colouration of the water and this water is been consumed by the miners in the area due to lack of alternative source for drinking water (Figure 6).

Figure 6. Polluted river water due to sand, gravel and gold mining in Luku Village

Figure 7. Dust generation due to drilling activity resulting in air pollution in Luku

6. Air Pollution

Air pollution is also one of the environmental impacts observed in the area. This air pollution resulted from the use of a jack hammer (Figure 7) to facilitate drilling which aroused dust particles in the air. Industrial minerals such as silica flux and very fine gypsum can result to such pollution which can cause irritation of the lungs and mucus membrane.

3.3 Geochemistry of Soil Samples

The result of the laboratory analysis of the soil samples is presented in Table 1 while the average concentration of these elements with average permissible standard concentration of elements in the upper continental crust by [9,10] is presented in Table 2.

Table 1. Concentration of trace element in the soil samples

Element (ppm)	LGS1	LGS2	LGS3	LGS4	LGS5	LGS6	LGS7	LGS8	LGS9	LGS10	Average value
Pb	43	82	91	4	13	6	6	14	26	143	42.8
As	2	7	1	0.2	10	3	4.5	4	1	9	4.17
Cu	48	82	39	41	56	67	42	46	43	45	50.9
Zn	51	11	9.6	9	56	67	42	46	43	45	37.96
Ni	15	10	23	31	90	39	20	36	45	18	32.7
V	53	79	47	86	100	30	40	70	60	12	57.7
Cr	1	15	3	3.6	4.1	1	2.2	2	1.7	1200	123.36
Ba	740	1060	1000	320	1000	370	660	510	690	480	683
Sr	22	350	713	48	371	52	53	51	77	658	239.5
Mn	514	700	1120	290	343	142	555	556	400	67	468.7
Cd	-	1	2	-	1	4	5.5	6.3	3	2	2.48
Sb	1	3	-	-	5	-	-	1	2	-	1.2
Co	12	-	6	11	-	12	4	11	-	3	5.9
Th	-	2	-	5	3	2	-	11	-	7	3
Mo	-	-	2	-	1	1	-	-	-	-	0.4
Hg	-	-	-	1	-	-	-	-	-	-	0.1
Ag	-	1	2	-	1	2	1	-	1	-	0.8
Sn	-	-	1	2	-	-	-	-	-	-	0.3
Au	-	0.1	0.2	-	-	1	0.6	0.3	-	0.8	0.3
Yb	-	-	4	-	-	-	-	1	-	-	0.5
Re	11	-	-	3	10	4	-	-	2	-	0.3
Ta	-	-	2	1	-	-	-	-	-	-	0.3
Eu	11	-	21	9	7	2	25	26	19	27	14.7
Y	14	-	12	12	10	15	25	24	31	21	16.4
Rb	27	5	-	2	37	6	-	29	4	43	15.3
Zr	551	710	920	170	893	223	241	226	101	926	496.1
Nb	8	42	4	32	11	6	2	8	-	7	12
Ga	-	-	40	20	-	-	10	15	21	9	11.5

Table 2. Average Concentration of selected element and their standard concentration in the upper continental crust

Elements	Average concentration from study area	Standard concentration by [9] (ppm)	Standard concentration by [10] in ppm
Pb	42.8	17	20
As	4.17	2.0	1.5
Cu	50.9	14.3	25
Zn	37.96	52	71
Ni	32.7	18.6	20
Mn	468.7	527	600
Cd	2.48	0.102	0.098
Co	5.9	11.6	10
Mo	0.4	1.4	1.5
Hg	0.1	0.056	-
Ag	0.8	0.055	0.05
Zr	496.1	237	190

3.4. Geochemistry

LEAD

From the result above, the concentration of lead (Pb) range from 4ppm to143ppm with an average concentration of42.8ppm (Table 1), while the standard concentration by [9,10] are 17ppm and 20ppm respectively (Table 2). Hence this shows that there is a high concentration of lead in the area and this has a negative impact on the environment and man. The inhabitants in this area partake in agricultural activities. Plants on the land may tend to absorb the lead through their roots and this plants if consumed by man and animals can result to lead poisoning. Lead poisoning is a medical condition in humans and other vertebrates caused by increased levels of the heavy metal in the body which can cause disorders to the heart, kidneys, reproductive and nervous system [11].

ARSENIC

From the result obtained from the study, the concentration of arsenic (As) in the study area range from 0.2ppm to 10ppm with an average concentration of 4.17ppm (Table 1), when compared to the standard concentration of 2.0ppm and 1.5ppm by [9,10] (Table 2), it shows that the concentration of arsenic in the area is higher than the required standards. The study area has rivers flowing through and arsenic can contaminate the water. Inhabitants and miners within the area depend on the water in the river for drinking and other uses due to lack of alternative source for water supply. Arsenic in drinking water, poses the greatest threat to public health [11]. Long term exposure to arsenic via drinking water causes cancer of the skin, lungs, urinary bladder and kidney.

COPPER

The concentration of copper(Cu) in the soil samples ranges from 39ppm to 82ppm with an average concentration of 50.9ppm (Table 1) compared to the standard of 14.5ppm and 25ppm by [9,10] respectively (Table 2). This shows that copper is in excess in the area. Environmental and health impacts associated to copper includes, on copper rich soils, only a limited number of plants has the chance to survive. Due to the effects upon plants copper is a serious threat to the production of farmlands, depending upon the acidity of the soil and presence of organic matter [11]. When soils and farmlands are polluted with copper, inhabitants and animals that depend on such plants will absorb concentrations that are damaging to their health, such as damages to the liver and kidney when ingested or breathed in excess.

NICKEL

The results above show that, the concentration of nickel (Ni) ranges from 15ppm-90ppm and an average concentration of 32.7ppm (Table 1) with standard averages of 18.6ppm and 20ppm, by [9,10] respectively (Table 2). This shows that the concentration of nickel in the area is high compared to the standards. High concentration of nickel in soils can damage plants and can cause various kinds of cancer on different sites within the bodies of animals.

CADMIUM

From the result, it is shown that cadmium (Cd) ranges from1ppm to 6.3ppm, with an average concentration of 2.48ppm (Table 1) when compared to the standard concentration of 0.102ppm and 0.098ppm by [9,10] respectively (Table 2). The comparism shows that the concentration of cadmium in the soils of the area is higher than the standard concentration in the upper continental crust. This can pose a threat to human because candium accumilated in the body takes a very long period of time to be excreted and may result in severe damage to the lungs via inhalation [11]. Cadmium strongly adsorbs to organic matter in soils and when present in large concentration in the soil, it can be extremely dangerous, as the uptake through food will iincrease. Soils that are acidified, enhance the cadmium uptake by plants. This is a potential danger to the animals that are dependent upon the plants for survival. Earthworms and other essential soil organisms are also extremely supsseptible to cadmium poisoning.

MERCURY

The results from the study show that the concentration of mercury (Hg) in the area is 1ppm with an average concentration of 0.1ppm (Table 1). When compared to the standard concentration of 0.056ppm by Wendepohl shows that mercury is of a higher concentration than the standard in the upper continental crust(Table 2). The high concentration of mercury in the soil can be absorbed by the plants, since the inhabitants in the area caryout agricultural poractices. Such plants, if consumed by man or animals can cause damage to the brain and kidney, lung irritation and also DNA alteration [11].

SILVER

The concentration of silver (Ag) ranges from 1ppm to 2ppm with an average concentration of 0.8ppm (Table 1). Comparing the concentration of silver to the standard concentration of 0.055ppm and 0.05ppm by [9,10] respectively shows that the concentration of silver in the area is higher (Table 2). Plants can absorb silver from the soil, and this plants are consumed by man and animals who depends on it for survival resulting to several health problems such as cardiac abnormalities to human, lung and liver damage to animals and even death [12].

ZIRCON

The concentration of zircon in the area ranges from 101ppm to 926ppm, with an average concentration of 496.1ppm. When compared to the standard concentration of 237ppm and 190ppm by [9,10] respectively, shows that the concentration of zircon in the area is higher than the standard concentration and this may contaminate the soil and water in the area.

However, the result of the analyses shows that the concentration of zinc (Zn) ranges from 9ppm-67ppm, with an average concentration of 37.96ppm, manganese (Mn) 67- 1120ppm and an average concentration of 468.7ppm, cobalt (Co) 3-12ppm with an average of 5.9ppm and molybdenum (Mo) 1-2ppm with an average of 0.4ppm (Table 1). The average concentrations of these elements in the soils of the study area is however lower than the average standard concentration in the upper continental crust. This therefore means that that the concentrations of these elements are low and this may have no negative effects on the environment.

4. Conclusions

The demand for sand and gravel for construction and other purposes is growing every day, and the process of mining these aggregates has resulted to serious environmental impacts. In Luku area of North Central Nigeria, sand and gravel mining has been going on at a large scale. Results of field work shows that destruction of landscape, deforestation, water pollution, loss of farm and grazing lands and the collapse of river banks are the physical environmental impacts associated with mining of these materials in the area. Result of analysis of soil samples indicates that lead, arsenic, copper, nickel, silver, mercury, zircon and cadmium have average values which are higher when compared to the standard approved concentration in the upper continental crust. The occurrence of these trace elements in excess in the soil and water, can have negative effects or lead to the death of man, animals and the destruction or extinction of some plants in the area. However, zinc, molybdenum, cobalt and manganese have average concentrations below the standard approved concentration in the upper continental crust and this may have no negative effects on the environment.

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