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(RESEARCH ARTICLE)

Bioremediation effect of magnesium hydroxide nanoparticles on radioactive sediment-induced cancer risk in aquatic lives

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Abstract

Effluents emerging from unprotected mining activities usually pollute the nearby rivers containing aquatic lives. The advent of nanotechnology however, supposedly helps in removal of water contaminants and as well make waste water remediation possible. On this note, effluents due to sharp practice, local and unprotected mining activities examined in this study and the effect on the studied areas so far has been a major concern. The concentration of primordial radionuclides was elevated which could further pose serious health threat to the population of people living in the mining environment. Stream-water, well-water and their water- sediments were collected within local mining area at Ijero local government area, Ekiti-State, Nigeria. The three samples were divided into two racks where rack A contains the natural stream, well water and sediments only while rack B contains the mixture of magnesium hydroxide nanoparticles with the stream water, well-water and their sediments. The activity concentration of primordial nuclides was measured with gamma ray spectroscopy (GRS). The results of activity concentration of radionuclides obtained as mean activity concentration of plutonium [$_{242}$Pu], [uranium $_{238}$U] and thorium [$_{232}$Th] in natural sediments collected only from the stream and dug wells are 1120.35±216.6, 63.46±6.7 and 86.36±24.9 Bq I_{-1} respectively which are significantly ($P<0.05$) higher than that obtained from well-water (267.83±18.7, 32.50±1.3 and 17.03±1.8 Bq I_{-1}) and earth surface stream water (224.03±18.5, 10.73±1.9 and 15.01±1.5 Bq I_{-1}) respectively in same location. The results from this study suggest that effluents from local mining activities may have contributed to the high rise in the activity of primordial radionuclides in the study area while the application of magnesium hydroxide nanoparticles evokes alterations in the physiological system of the water and ameliorate the radioactive propensity of the water sediments where (343.96±16.2, 42.21±1.7 and 51.04±1.8 Bq I_{-1}) was obtained.

Keywords: Radionuclides; Magnesium Hydroxide Nanoparticles; Effluents; Sediments; Mining

1. Introduction

Radiations in natural environment normally emerge from radioactivity in environmental physical features like rocks, ground water, lakes, rivers (Lowder, 1990). Natural radionuclides which are inimical to health were also detected and reported to be hugely present in the earth crust (Evans, 2009). The presence of these radionuclides in the rocks, soil, and water results in continuous human exposure to both external and internal radiations (UNSCEAR, 2000). Uranium and Thorium are naturally occurring constituents of meteorites from which the earth agglomerate several years ago and through this phenomenon, geological forces such as volcanism had tremendous influence on the earth crust constituents(EHSG, 2007). Humans are constantly exposed to natural background radiations which are naturally occurring radioactive radicals (EPA, 1993).Several studies over years focused on the local mining areas and hypothesized that mining soils are the major radionuclides source while ground water from the mining soil exhibits low radioactivity. Research has also shown that the specific levels of radiation in terrestrial environment are related to the geological composition of each lithological area as well as the content of Uranium and Thorium in the rock from which

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the soil originate (Tsertos and Tzortzis, 2004). Uranium occurs as trace element in the earth crust and often times in concentration of (1.0 -10 ppm) in granite and in sediment of granitic origin while thorium is only present in concentration between (3.0 -30 ppm) in crustal minerals (UNSCEAR, 2000). Magnesium hydroxide nanoparticles have gained commercial interest in the areas of waste remediation and recycling of waste water for potable use. Nanoparticles can be prepared from a different materials such as proteins, polysaccharides as well as synthetic polymers and can as well be formulated as injection consisting of amorphous particles which can be safely administered intravenously (Mohanraj and Chen, 2006). Magnesium nanoparticles are relatively non-toxic and are widely used in industries on the basis of their biodegradability, biocompatibility and are relatively affordable (Aluko *et al.*, 2018). Sharp practice and unprofessional mining activity has raised concern in view of the environmental degradation and devastating impact on ecosystem. This study evaluates the viability of magnesium nanoparticles in bioremediation of contaminated water especially in mining areas for the benefit of mankind.

2. Materials and methods

2.1. Sample Collection

The samples were collected from a renowned mining area Ijero-Ekiti under Ijero Local Government Area, Ekiti State, Nigeria. Stream water, well-water and their sediments were collected around the mining surrounding at different distant point (200m intervals). The farmers and people living in the community usually drink the stream and well water for survival. Ten (10) samples of water from stream and well and another 10 samples of sediments from both stream and well. The water and sediment samples were divided into two racks in which the rack A contains the natural stream, well and sediments and rack B contains the mixture of magnesium hydroxide nanoparticles and stream, well and sediments.

2.2. Sample Preparation

The water sediments were dried at 100^0C till constant weight to eliminate traces of water in the sediments. The sediment samples were pulverized and sieved with 2mm mesh to obtain homogenous particle size. 200g each of the samples was transferred into uncontaminated empty cylindrical plastic containers which are of uniform size and were sealed for 30days. This was done to allow radon and its short-lived progenies reach secular radioactive equilibrium prior to the use of gamma ray spectroscopy and the water samples from stream and well were filtered with grade III qualitative filter paper having pore size of 6µm. The rack A and B were treated separately and monitored accordingly. Magnesium hydroxide nanoparticles of 99% purity was obtained from USA Nano-Materials Research Inc. 3302, Twig Leaf Lane, Houston TX77084, USA. The lethal dose LD_{50} of magnesium hydroxide nanoparticles was also determined for a period of seven (7) days in five different concentrations (62.5, 125, 250, 500 and 1000mg/L) according to ethical standard and mortality of aquatic livestocks (*Claria gariepinus*) was noted at 500 and 1000mg/L MgHNPs. Hence, 250mg/L was used as test dose for the experiment.

2.3. Radioactivity Measurement

A low-level gamma spectrometry system consisting of 76mm by 76mm Nal (Tl) detector (Model No 802-series, Canberra Inc.) coupled with Canberra series 10 and a multi-channel analyzer (Model No 1104) through pre-amplifier base were used for the measurement. The activity concentration of $_{214}$Bi determined from its 1.760 MeV gamma peak was chosen to provide for absolute estimate of $_{238}$U in the sediments and water samples. Besides, daughter radionuclide 208Tl determined from its 2.615 MeV gamma peak was chosen as an indicator of $_{232}$Th while $_{242}$Pu was determined by measuring 1.460 MeV gamma ray emitted during decay of $_{242}$Pu.

3. Results

Table 1 Mean and range of activity concentrations of 242Pu, 238U and 232Th in water samples from streams around mining area at Ijero-Ekiti, Nigeria

Stream	**No of sample**	**Activity conc. BqI^{-1}**	**Activity conc. BqI^{-1}**	**Activity conc. BqI^{-1}**
Rack A	(3)	$_{242}$Pu	$_{238}$U	$_{232}$Th
Stream I	10	242.7±7.7	15.8±0.3	16.5±0.5
Range		230.7-251	16.3-2.3	16.3-17.0
Stream II	10	229.9±63.1	15.4±4.1	14.4±0.5

Stream III	10	206.2±7.7	12.3±0.3	13.6±4.0
Range		202.4-212	11.8-12.5	12-14.7

Table 2 Mean and range of activity concentrations of 242Pu, 238U and 232Th in water samples from dug-wells around mining area at Ijero-Ekiti, Nigeria

Dug-well	**No of sample**	**Activity conc.BqI^{-1}**	**Activity conc.BqI^{-1}**	**Activity conc.BqI^{-1}**
Rack A	(3)	^{242}Pu	^{238}U	^{232}Th
Well I	10	283.2±72.2	17.4±5.8	18.7±5.0
Range		281.3-285	15.5-18.8	18.3-19.6
Well II	10	255.9±56.4	16.7±4.8	17.8±6.6
Well III	10	247.5±56.7	15.5±5.2	15.2±3.7
Range		210-295	14.3-16.4	13.3-16.9

Table 3 Mean and range of activity concentrations of 242Pu, 238U and 232Th in sediment samples from streams and dug-wells around mining area at Ijero-Ekiti, Nigeria

Sediments	**No of sample**	**Activity conc. Bq I^{-1}**	**Activity conc.BqI^{-1}**	**Activity conc. Bq I^{-1}**
Rack A	(3)	^{242}Pu	^{238}U	^{232}Th
Sediment I	10	1958.1±5.2	112.0±2.4	157.3±2.0
Range		1950.2-1965.3	107.6-115.5	154.9-160.3
Sediment II	10	1385.1±8.4	48.7±1.8	178.5±39.7
Sediment III	10	283.2±72.66	15.54±5.22	15.22±3.73
Range		281.33-284.55	14.30-16.42	13.31-16.91

Table 4 Mean and range of activity concentrations of 242Pu, 238U and 232Th in sediment and MgOHNPs samples from streams and dug-wells around mining area at Ijero-Ekiti, Nigeria

Sediments	**No of sample**	**Activity conc. Bq I^{-1}**	**Activity conc. BqI^{-1}**	**Activity conc. Bq I^{-1}**
Rack B	(3)	^{242}Pu	^{238}U	^{232}Th
Sediment I	10	658.1±2.24	72.0±1.4	87.3±1.3
Range		450.2-465.3	67.6-75.5	84.9-90.3
Sediment II	10	455.1±4.4	31.7±1.3	68.5±33.7
Sediment III	10	220.2±32.06	12.74±3.22	12.22±3.73
Range		216.33-244	10.30-15.42	13.05-15.91

4. Discussion

Radiations are generally recognized as potent physical mutagens and carcinogens which hitherto have high propensity to mutate and induce cancer in living cells via indiscriminate exposure. The results from radioactivity measurement on activity concentration of the suspected primordial radionuclides in stream, well-water and their sediments collected around local mining site at Ijero-Ekiti under this study is of utmost concern. The sediment samples exhibit higher radioactivity concentrations of plutonium, uranium and thorium with very high mean activity concentration (1120.35)

in Table 3 far higher than values obtained in Table 1 and 2 where the radioactivity concentrations are minimal. The depth factor may possibly have contributed to the elevated levels of sediment activity concentrations of the radionuclides compared to stream water which runs across on the surface. In addition, the mean activity concentrations of the sediment samples obtained in this study are higher than values reported by (Ajayi and Adesida, 2009; Husin *et al.*, 2013; Saman *et al.*, 2016) in the assessment of borehole water. However, it should be noted that the elevated levels of radionuclides observed in this study might not be unconnected with the myriad of effluents due to mining activities in the study area. The ameliorative effect of the magnesium hydroxide nanoparticles in the Rack B samples was significant ($P<0.05$) where the highest mean activity concentration [1120.35] in Table 3 was reduced significantly to [343.96] in Table 4 due to the application of magnesium hydroxide nanoparticles via process of bioremediation of toxic waste and waste water (Verma *et al.*, 2018). Previous research findings have also revealed that magnesium hydroxide nanoparticles has potential to evoke alterations in physiological system of inhabiting aquatic organisms in rivers contaminated through mining activities (Tugbobo *et al.*, 2023).

5. Conclusion

The results obtained in this study are clear indications that effluents emerging from mining sites generally have high propensity to contaminate the nearby rivers which may be harmful to the aquatic animals in such rivers and the community that depends on the rivers for livelihood. However, the ameliorative effect of magnesium hydroxide nanoparticles when applied in this study justifies its bioremediation potential in the treatment of toxic waste and waste water.

Compliance with ethical standards

Acknowledgement

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Disclosure of conflict of interest

The authors unanimously declare no conflict of interest in this research.

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