Risk Assessment of Water Pollution on Sediments in Taungthaman Lake

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Abstract

Two sediment types with water pollution and without water pollution were examined to investigate the heavy metal pollution of the sediments by the EDXRF method and the radionuclides contained in the sediments by Gamma Spectroscopy. Major and trace elements distribution were determined by EDXRF method. The concentration of chromium (Cr) was found in top part sediment but not found in bottom part sediment with water pollution. The concentration of cupper (Cu) was found in both top part and bottom part sediments without water pollution. The gamma activities of two top part sediments with and without water pollution were measured with NaI (Tl) gamma ray spectrometer by using Gamma-Vision 32 Software. By analyzing the spectra, the following radioisotopes were observed. They are ^{212}Pb, ^{214}Pb, ^{208}Tl, ^{228}Ac and ^{214}Bi. The activities of ^{212}Pb and ^{228}Ac exceed the recommended activity concentrations of IAEA-385 Reference Material.

Introduction

Environmental pollution is happening in many parts of the world, especially in form of air and water pollution. Soil and water resources are extremely exposed to pollution from different aspects. The most common pollutants are usually chemicals, garbage, and waste water.

Chemical industries in particular, have created severe problems, since they release thousands of chemicals to the environment. Studies on the effect of environmental pollutants on vegetation have been carried out .On the other hand, the importance of heavy metals as environmental pollutants is well documented in literature. It is reported that the most toxic elements to plants when present in excess are Cd, Cu, Pb and Zn, but damage may also be caused by As, B, Cr, Hg, Mn, Me, Ni and Se. The research is to estimate the sediment pollution due to the residue water from the factories.

The main focus of the research is to investigate the existence of heavy metal pollution and the radionuclide contained in the sediments during waste water flooding and sinking at a fixed location near U Shwe Tun bridge in Taungthaman Lake.

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Materials and Methods

Description of Research Area

Taungthaman Lake is situated in Amarapura Township within the Mandalay Region. Taungthaman Lake has length above two miles from east to west, its width one mile. Lake area is 231.73 acres. Taungthaman Lake is an oxbow lake in which water floods from the Ayeyarwaddy and Dotawady River during the rainy season. But water level goes down in winter and summer season. It is used for fisheries. In this study sediment samples were taken from the fixed sampling site under the bridge where the water comes in the rainy season.

Sample Location (Sampling Site), Collection and Preparation

The fixed sampling site is located at (Lat 21 º 53´ 59.25 (N) to Long 96º 04´34.67 (E) in Amarapura Township. The sample location is shown in Figure (1).Two sediment samples from the research site were each collected with two inches in diameter PVC pipe which is two feet long. The top part sediment S1 was taken from the upper end of the pipe The bottom part sediments S2 were also collected from lowest part of the same pipe from the 1feet depth. The sediments S1 and S2 during water pollution were collected in September. Similarly the top part sediments S3 and bottom part sediments S4 were also collected with the pipe in November. The photograph of two PVC pipes for sample collection is shown in Figure (2).For gamma detection system, the samples preparation like drying, grinding, homogenization and packing in proper geometrical dimensions for gamma spectrometric analysis was carried out for sediment samples. The sediment samples were dried at room temperature, avoiding the loss of any volatile radionuclides. The dried sediments were pulverized and sieved to pass through a 1-2 mm mesh. The meshed sediments were transferred to plastic containers of 600g capacity for gamma activity analysis.

Energy Dispersive X-Ray Spectrometer (EDXRF) Method in Universities'Research Center, Yangon University

The four sediments S1,S2,S3 and S4 were investigated in EDXRF spectrometer in Universities' Research Center, Yangon University. The photograph of X ray spectrometer is shown in Figure (3).

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Experimental Procedure for Gamma Spectroscopy

The two sediment samples were investigated with Gamma Emission Measurement. In gamma ray spectrometry system, the following equipments are included. They are NaI (Tl) scintillation detector associated with ORTEC (Model 296) photomultiplier tube, high voltage power supply, preamplifier (Model 142 PC), fast spectroscopy amplifier (Model 671), a pulse stored multi-channel analyzer (MCA) together with Gamma Vision 32 software installed in PC. The high voltage power supply was used for supplying the potentials for the detector. The operating voltage for NaI (Tl) scintillation detector is 1000V. The 3" x 3" NaI (Tl) Scintillation detector was used to detect the gamma radiation intensity before and after passing though the absorbing material and this information (electronic pulses) was amplified and stored in MCA based on personal computer. . The whole system including detector and all other modules were from ORTEC.

This experimental setting was fixed for throughout the whole research laboratory measurement. In this research, the standard gamma sources ^{241}Am (activity = 5μCi, half-life = 40 years, energy =60.00 keV), ^{54}Mn (activity = 1μCi, half-life =313 days, energy =835.00 keV), ^{137}Cs (activity = 1μCi, half-life = 30.2 years, energy = 661.65 keV) and ^{60}Co (activity = 1μCi, half-life = 5.27 years, energy = 1173.23 keV and 1332.49 keV) were used for energy

calibration. The calibration time was 300 seconds. These sources except ^{241}Am have manufactured in May 2013.

The lead (Pb) shielding was used to shield cosmic rays and other radiations in environment. In this work, conversion gain was set at 2048.Coarse gain was fixed at 20 and fine gain was 8.7. Shaping time was 1 μ second. Real time was set at 15000 seconds and live time was set at 7200 seconds.

By the putting polythene container on the NaI (Tl) scintillation detector, the background was measured for two hours. The sediment samples were placed in container and were measured for about two hours. Using the displayed energy information, an unknown radioisotope can be identified radionuclides with activity concentrations and a picture of the spectrum and then determined by the gross area and net area of full energy peak. The photograph of the experimental arrangement for detecting system is shown in Figure (4). Intensity of gamma-rays spectrum lines were calculated by using the equation (1).The equation of the activity of the sample is

$$\mathbf{A_{sample} = \frac{C_{sample}}{\varepsilon W P_{\gamma}}} \qquad (1)$$

A_{sample} = Activity of the samples (Bq/kg)

C_{sample} = Net count rate for sample

W = Weight of the sample under the NaI(Tl) crystal in kg

P_{γ} = Gamma emission probability for energy E

ε = Full energy peak efficiency

Figure (1) The sample location in Taungthaman Lake

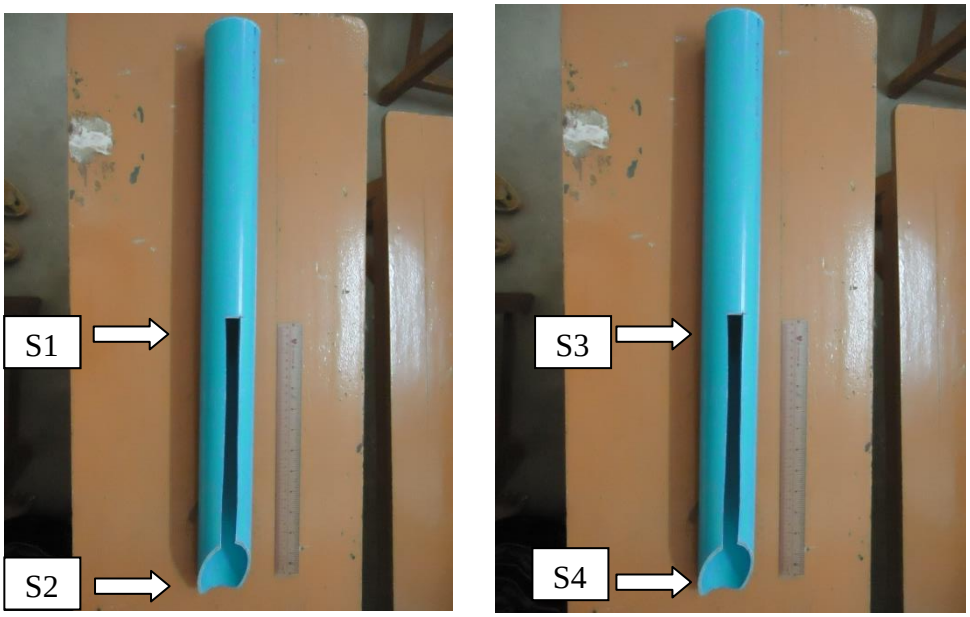


Figure (2) The photograph of two PVC pipes for sample collection

Figure (3) The photograph of X ray spectrometer

Figure (4) Photograph of Experimental Arrangement for Gamma Detecting System

Results and Discussions

The four sediment samples were investigated with EDXRF method .The EDXRF report for the elemental concentration for four sediment samples is given in Table (1). The elemental concentrations of Iron(Fe),Potassium (K), Calcium (Ca), Tatanium (Ti),Manganese (Mn), Zirconium (Zr),Zinc(Zn),Strontium (Sr) and Yttrium(Y) except Silicon (Si) in the sediment with water pollution is higher than the sediment without water pollution in the EDXRF results. The elemental concentrations of Fe, K, Ca, Ti, Mn, Zr, Zn, Sr and Y except Si in the sediment flow in water is grater than in the sediment flow out water.The comparisons of elemental concentration are shown in Figure(5) to Figure (8).In gamma detection system, the sediment samples S1 and S3 were determined with NaI(Tl) scintillation detector. The concentration of these nuclides in sediment samples were calculated by using measured data and literature values. Results of sediment samples are identified by analysis of Gamma Vision Software. Results are shown in Table (2). Results of samples observed are ^{208}Tl and ^{228}Ac daughter nuclei in ^{232}Th decay series, which are shown in Figure (9). The samples observed are ^{214}Pb, ^{214}Bi and^{234}Th daughter nuclei in the ^{238}U decay series as shown in Figure (10). Although the half-life of the elements is short, according to the continuous spectrum of the samples, it can be assumed that there must be parent nuclei existing in them. The Table (3) is the radionuclides concentrations (Bq/kg) obtained from IAEA-385 reference material (Irish Sea Sediment).The activities of the radionuclides contained in the two sediments are given in Table (4). From Table (3) and Table (4), it can be seen that the activity concentration in the present research is less than that of IAEA-385 except^{212}Pb and ^{228}Ac .The activities of ^{212}Pb and ^{228}Ac exceed the recommended activity concentrations of IAEA-385 Reference Material. The comparison of gamma spectra of background and sediment samples with water pollution is shown Figure (11). The comparison of gamma spectra of background and sediment samples without water pollution is shown Figure (12).

Table (1) The elemental concentrations for four sediment samples in EDXRF Analysis

Element	Concentration (%)			
	S1 (with water pollution)	S2 (with water pollution)	S3 (without water pollution)	S4 (without water pollution)
Si	62.697	57.858	66.970	63.325
Fe	19.664	23.783	17.959	21.954
K	7.725	8.056	7.0885	7.700
Ca	7.399	7.464	5.752	4.377
Ti	1.891	2.176	1.670	2.010
Mn	0.223	0.269	0.209	0.233
Zr	0.140	0.171	0.127	0.131
Zn	0.097	0.101	0.090	0.073
Rb	ND	ND	ND	0.054
Sr	0.060%	0.072	0.050	0.052
Y	0.037	0.049	0.034	0.046
Cu	ND	ND	0.053	0.045
Cr	0`.067	ND	ND	ND-

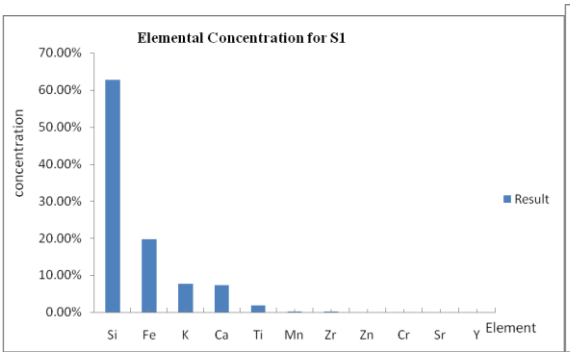


Figure (5) Elemental Concentration for S1

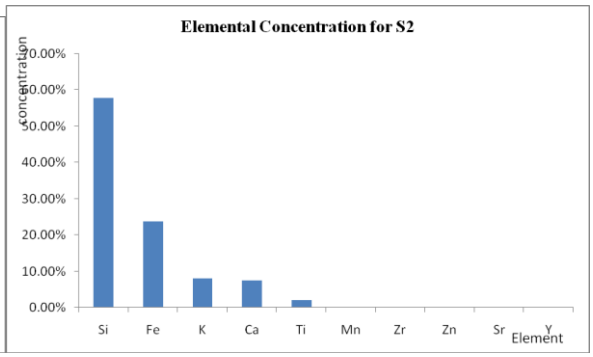


Figure (6) Elemental Concentration for S2

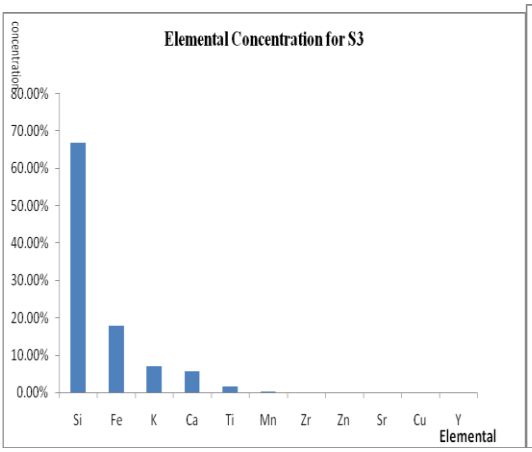


Figure (y) Elemental Concentration for S3

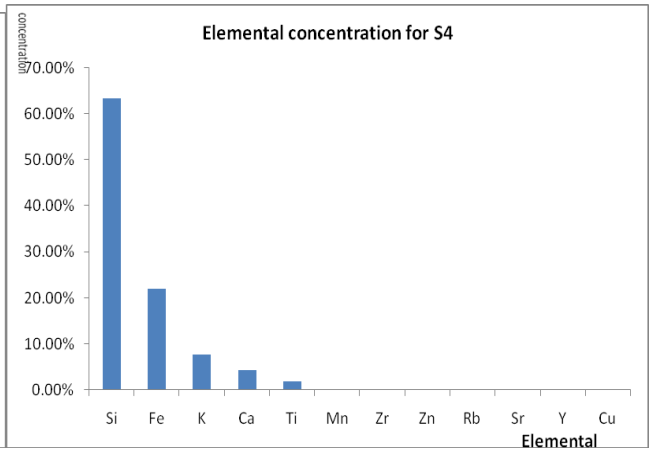


Figure (8) Elemental Concentration for S4

Table (2) Radionuclides Present in Two Sediment Samples investigated by γ-ray Spectroscopy using NaI(Tl) Detector

Radionuclide	Energy (keV)	Gamma Emission Probability (%)	Half-Life
^{234}Th	69.92	2.419	24.10 d
^{212}Pb	238.89	43.30	10.64 h
^{212}Pb	300.08	3.28	10.64 h
^{214}Pb	352.28	37.6	26.80 m
^{208}Tl	582.99	84.5	3.05 m
^{228}Ac	911.51	25.8	6.15 h
^{214}Bi	1051.96	0.315	19.90 m
^{40}K	1464.93	11	1.28 E9 y
^{214}Bi	1662.86	2.92	19.90 m

Table (3) Radionuclide Concentrations (Bq/kg) Obtained from IAEA-385 Reference Material (Irish Sea Sediment)

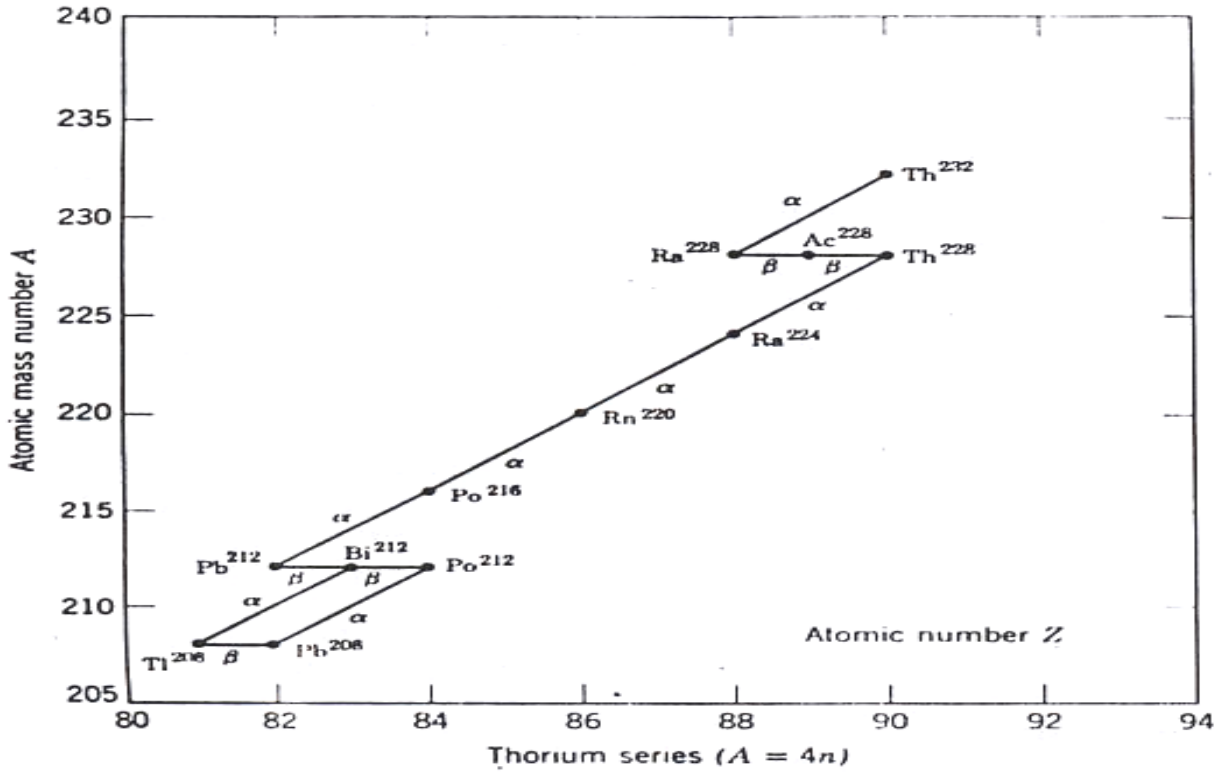
Isotope	95%Confidence Interval (Bq/kg)
^{212}Pb	33.0-39.0
^{214}Pb	20.0-22.4
^{226}Ra	21.8-24.0
^{234}Th	22.4-34.1
^{208}Tl	9.3-13.5
^{228}Ac	29.8-32.6
^{214}Bi	17.8-21.0
^{40}K	603-625
^{238}U	28.0-30.5

Revision of the reference sheet dated January (1996)

Table (4) Activity Concentration of Different Radionuclide in two SedimentsSamples

Sediment Sample Sites	Activity concentration (Bq kg^{-1})								
	^{134}Th	^{212}Pb	^{212}Pb	^{214}Pb	^{208}Tl	^{228}Ac	^{214}Bi	^{40}K	^{214}Bi
S1	74.68	3.35	65.95	2.00	10.71	43.42	-	341.25	-

S3	66.04	2.52	55.11	0.50	8.22	37.52	-	235.54	-



Figure(9) Thorium series

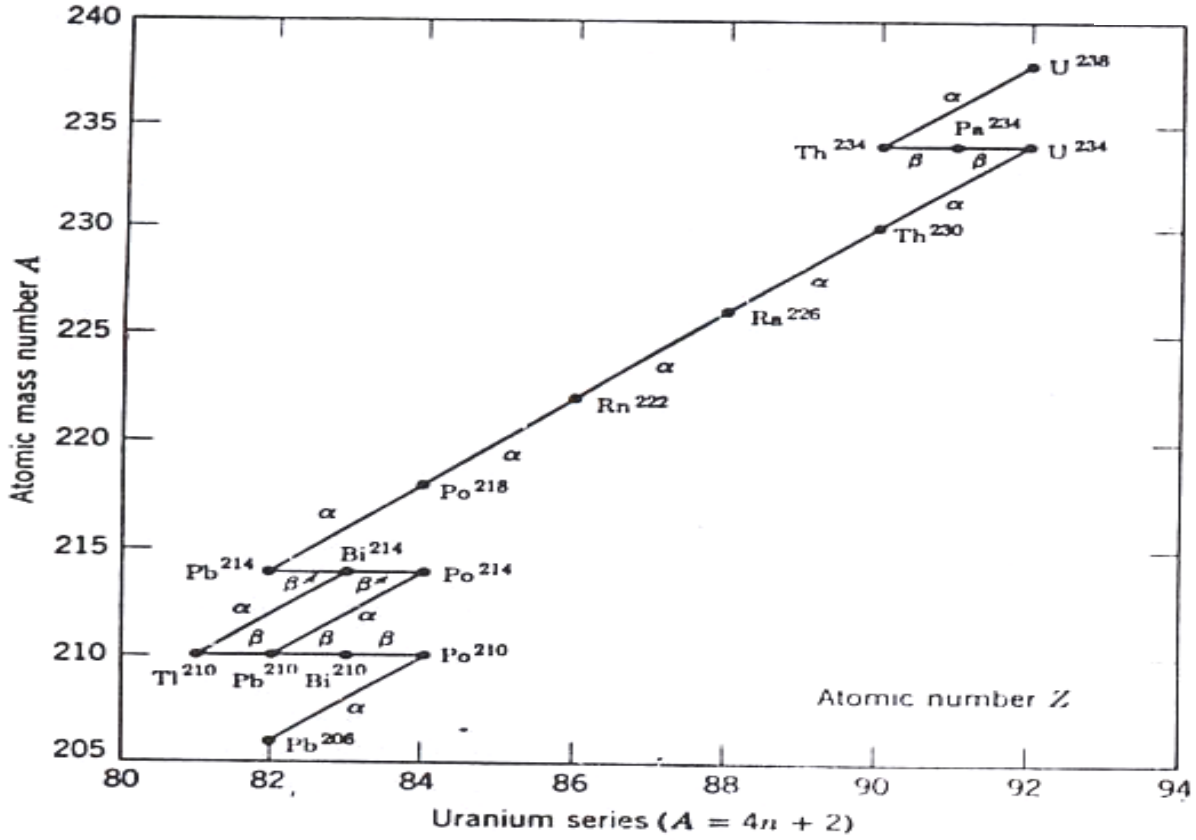


Figure (10) Thorium series

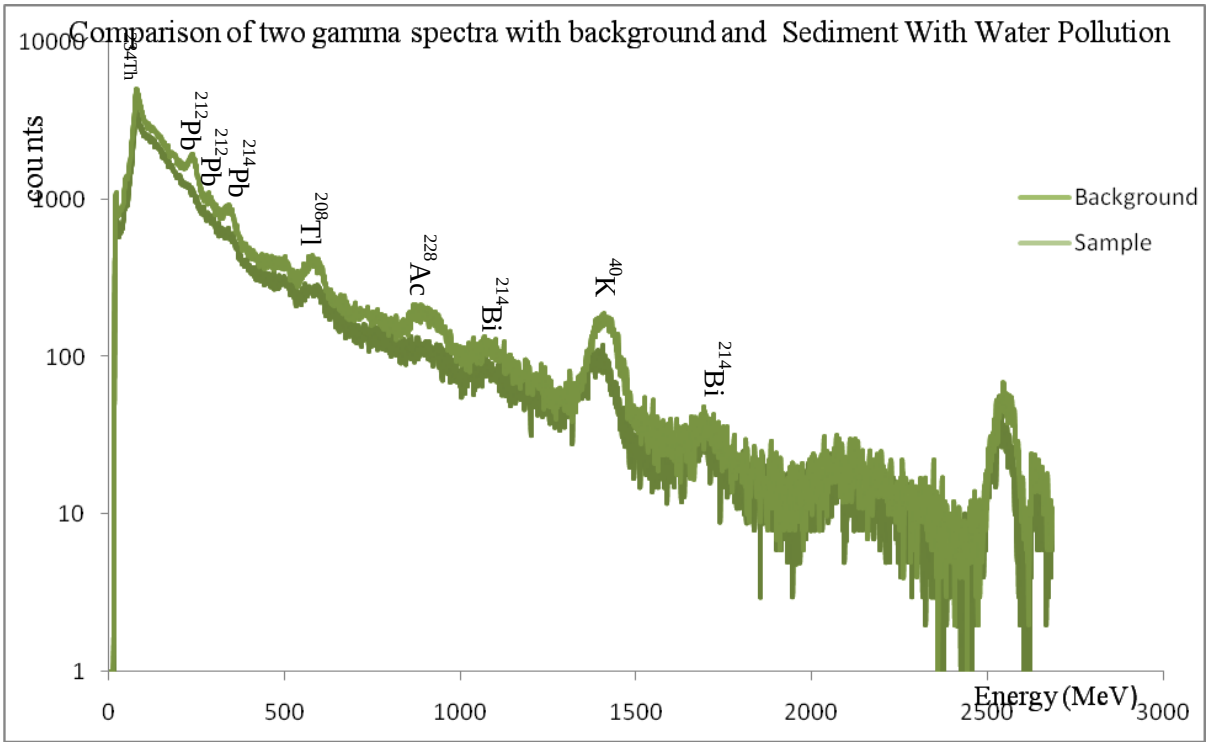


Figure (11) Comparison of gamma spectra with background and sediment sample within water pollution

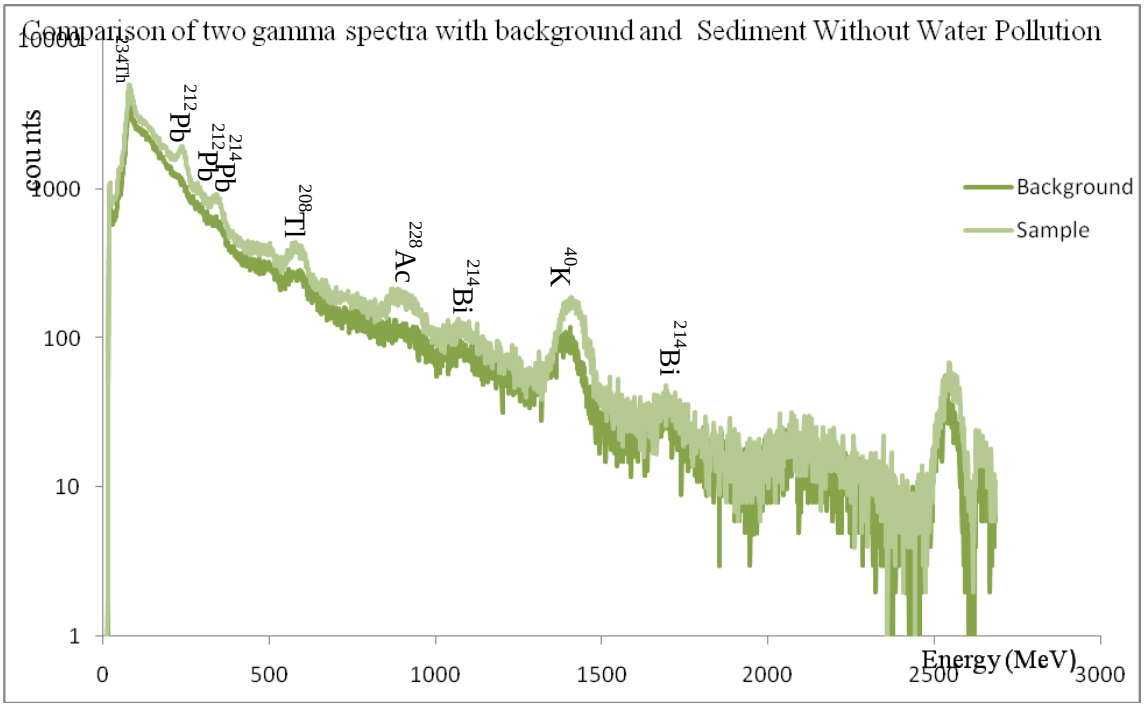


Figure (12) Comparison of gamma spectra with background and sediment sample without water pollution

Conclusion

The concentration of chromium (Cr) was found in top part sediment but not found in bottom part sediment with water pollution. The concentration of cupper (Cu) was found in both top part and bottom part sediments without water pollution according to EDXRF technique. It can be determined via ^{234}Th, which has gamma emissions at 63.3, 92.4, and 92.8 keV secular equilibrium being assumed. Measurement of ^{235}U which emits gamma photons at 185. 7keV. ^{228}Th is determined by measuring the gamma peaks emitted from its daughters, 238keV ^{212}Pb and 241keV ^{226}Ra or 583.1keV ^{208}Tl. ^{226}Ra is determined by measuring its own gamma emissions at 186.5keV if it is separated from ^{235}U (IAEA, 1990). But ^{226}Ra was not found in the research area. Alternatively, in the growth of its photo-emitting daughters, ^{214}Bi and ^{214}Pb may be measured, either directly or by using chemical separation and preconcentration.

The results show that a few components hazardous to health and small toxic chemical substances were found. Activities of all radioactive nuclei were low level except ^{212}Pb and ^{228}Ac. The radionuclides found in the measured samples were the products of ^{238}U and ^{232}Th natural radioactive series. Therefore, it is expected that ^{238}U and ^{232}Th can be concentrated in sediments of the research area. Therefore, further studies will be undertaken for several years to detect the status of these elements in sediment.

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