NATURAL RADIONUCLIDE DATING FOR CALCULATION OF SEDIMENT ACCUMULATION IN WETLAND SEDIMENTS

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ABSTRACT

Wetlands are one of the most important ecosystems with natural functions and economic values. Wetlands act as regulators of water regimes, behaving like a sponge that absorbs excess water and enhances the water quality. Another function of wetlands is providing natural diversity. Nowadays, wetlands, frequently defined as swamps or marshes, have great importance in terms of their functions and as habitats for a wide variety of organisms.

The depth-dependent temporal distribution of element concentrations in wetland sediments is a very valuable source for determining distributions of elements in water, together with the flux and rate of accumulation, to obtain the chronology of natural and human-induced events in the ecosystem and their impacts. Nuclear techniques used in this study have improved in the last forty years. In sedimentation studies radiometric dating techniques are used to calculate the sediment accumulation rate.

In this study, sediment accumulation rate calculated up to 40 cm below surface from the San Joaquin River National Wildlife Refuge (SJRNWR) which receives seasonal agricultural drainage from irrigated cropland has been investigated. Sedimentation rates in wetland sediment cores were measured with the ^{210}Pb technique and sediment accumulation rates were determined in each sediment layers. ^{210}Pb determinations were done via gamma spectrometric measurements. Profile distributions of ^{210}Pb were calculated by using CRS (Constant Rate of Supply) mathematical models in sedimentation rate calculations.

Keywords: Wetlands, Sediment Core, Sedimentation Rate, Dating, Lead-210 (^{210}Pb), CRS.

1. Introduction

Wetlands are one of the most important ecosystems with natural functions and economic values. Wetlands act as regulators of water regimes, behaving like a sponge that absorbs excess water and enhances the water quality. Another function of wetlands is providing natural diversity. Nowadays, wetlands, frequently defined as swamps or marshes, have great importance in terms of their functions and as habitats for a wide variety of organisms. Wetlands are located at the interface between terrestrial uplands and aquatic systems in agricultural watersheds. Agricultural runoff which is a major source of diffuse pollution worldwide may be dominated by runoff from cropland to the wetlands. Agricultural drainage contributes to the widespread eutrophication and the processes occurring in wetland systems affect downstream water quality as water and associated sediments flow into streams.

The depth-dependent temporal distribution of element concentrations in wetland sediments is a very valuable source for determining distributions of elements in water, together with the flux and rate of accumulation, to obtain the chronology of natural and human-induced events in the ecosystem and their impacts [1, 2]. Nuclear techniques used in this study have improved in the last forty years. In nuclear techniques, ^{210}Pb geochronology is a widely used tool in sediment accumulation rate studies aimed at the absolute ages of sediments (up to 100 years).

In this study, sediment accumulation rate calculated up to 40 cm below surface from the San Joaquin River National Wildlife Refuge (SJRNWR) which receives seasonal agricultural drainage from irrigated cropland has been investigated.

2. Material and methods

The SJRNWR is located on the west side of the San Joaquin River and it receive variable pulse in-flows of agricultural drainage during irrigation periods (April–October). The SJRNWR study site is former farmland that is being restored to a managed riparian wetland by the US Fish and Wildlife Service. The SJRNWR study site is a 270010 m^2, riparian wetland with an average depth of approximately 0.6 m. It has a drainage area of 38.45 km^2. Dominant vegetation at the SJRNWR include native willows (Salix exigua and Salix goodingii), annual fireweed (Epilobium brachycarpum), and bermuda grass (Cynodon dactylon) [3, 4].

Figure 1: Location of sediment cores collected from Refuge

In this study, sedimentation rates in wetland sediment cores were measured with the ^{210}Pb technique and sediment accumulation rates were determined in each sediment layers taken from seasonally flooded areas in SJRNWR. Two intact cores were collected using AMS Multi-stage Sludge and Sediment sampling kit. Collected samples were capped on both ends and returned to the laboratory where they were stored at 4° C in the dark until analyzed. For the analysis each soil core was carefully extruded from the tube into a U shaped cradle and sectioned with a blade into 5 cm lengths. These samples were dried at 105º C for 24 hours, ground with a mortar and pestle and then homogenized to a fine powder in a ball-beater homogenizer (VWR, USA). Processed samples were stored in sealed vials at room temperature until analysis.

^{210}Pb determinations were done via gamma spectrometric measurements. ^{210}Pb activity was determined by counting soil samples at least for 24 h at 46.5 keV using a high-purity germanium (2.08% efficiency) detector (Canberra). Counting efficiency was determined by counting a ^{210}Pb standard of the same geometry[5].

3. Results

Profile distributions of ^{210}Pb were calculated by using CRS (Constant Rate of Supply) mathematical model in sedimentation rate calculations [6-8]. The results are tabulated in Table 1 and Table 2.

The highest ^{210}Pb activity is 38.1 Bq/kg in SJR_CR_1 and 42.6 Bq/kg in SJR_CR_2. The profiles of excess ^{210}Pb of SJR_CR_1 and SJR_CR_2 have little variation with depth.

The profiles of accumulation rate changes with depth are graphically shown in Figure 2.

The result show that sediment accumulation rates in SJR_CR_1 varied from 0.78 to 3.23 g/cm^2.y and in SJR_CR_2 varied from 0.47 to 3.68 g/cm^2.y. The accumulation rate profile in two cores are similar and have highest value in 5 cm.

Table 1: Analysis data using CRS model to calculate the age and accumulation rates of sediment each layer of SJR_CR_1

Core	Depth, cm	$^{210}Pb_{xs}$(Bq/kg)	t, year	r, cm/y	r, g/cm^2.y
SJR_CR_1-1	2.5	24.4	3.2	1.55	3.23
SJR_CR_1-2	7.5	36.4	5.5	0.91	1.89
SJR_CR_1-3	12.5	24.7	4.4	1.15	2.39
SJR_CR_1-4	17.5	32.4	6.8	0.74	1.54
SJR_CR_1-5	22.5	25.8	6.7	0.75	1.56
SJR_CR_1-6	27.5	38.1	13.4	0.37	0.78

Table 2: Analysis data using CRS model to calculate the age and accumulation rates of sediment each layer of SJR_CR_2

Core	Depth, cm	$^{210}Pb_{xs}$(Bq/kg)	t, year	r, cm/y	r, g/cm^2.y
SJR_CR_2-1	2.5	24.4	2.9	1.73	3.68
SJR_CR_2-2	7.5	32.5	4.3	1.16	2.47
SJR_CR_2-3	12.5	40.7	6.3	0.79	1.67
SJR_CR_2-4	17.5	23.9	4.4	1.13	2.41
SJR_CR_2-5	22.5	40.7	9.3	0.54	1.15
SJR_CR_2-6	27.5	37	11.6	0.43	0.91
SJR_CR_2-7	32.5	42.6	22.4	0.22	0.47

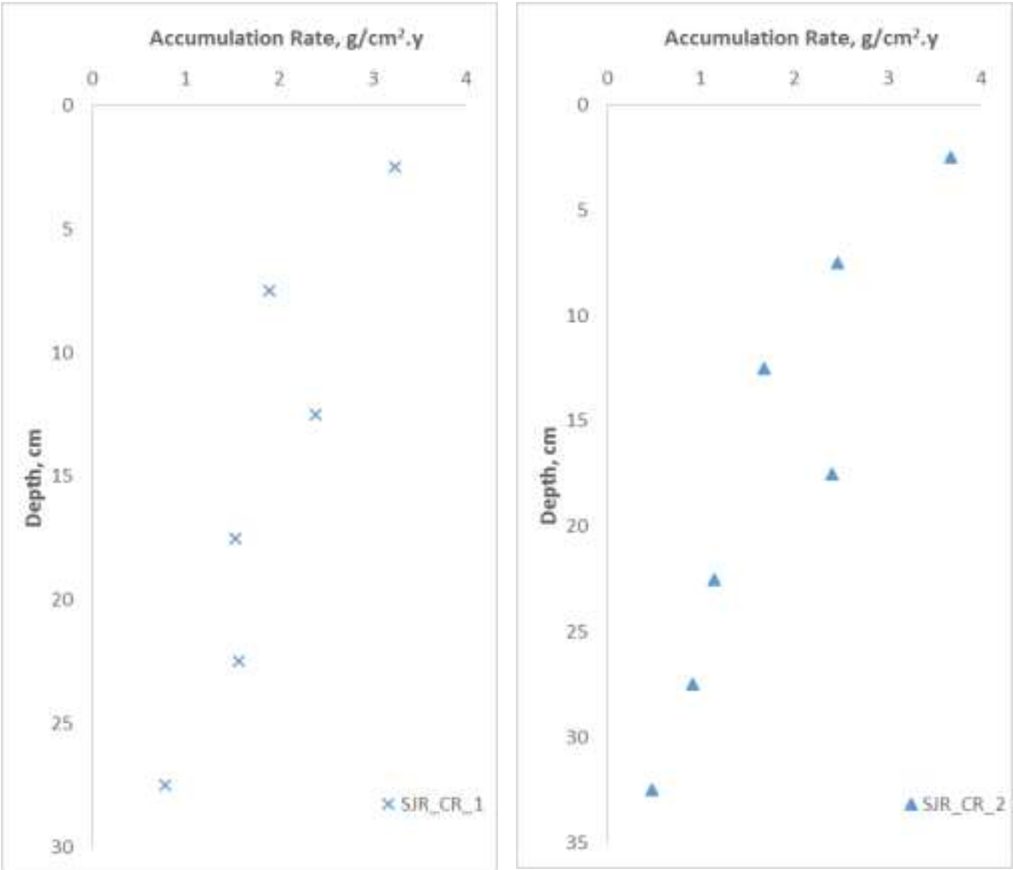

Figure 2: Accumulation rate versus depth for SJR_CR_1 and SJR_CR_2

4. Conclusions

Highest sedimentation rate calculated by CRS model is observed at seasonal wetland area as 3.68 g/cm^2.y in first 5 cm. The sediment accumulation rate decreases by the depth for two cores. Two cores displayed increases in accumulation rates of sediment since 2007. Bottom sediments of core SJR_CR_1 (25 – 30 cm) and core SJR_CR_2 (30 - 35 cm) were dated as year of 1998 and 1989, respectively. Therefore, sediment accumulation rates were slightly constant after 15 cm.

ACKNOWLEDGEMENTS

The authors are indebted to the research fund of the Anadolu University for supporting this study under a project entitled “Natural Radionuclide Dating for Calculation of Carbon and Nutrient Accumulation in Wetland Sediments” under project number 1305F105.

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