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Using C14 isotope in determining sedimentation rate in non–turbulent aquatic environment

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ABSTRACT

Sediments sequences provide a wealth of useful information to research concerning ancient environment and climatic changes. Non–turbulent aquatic environments including wetlands are remarkable instances to generate these sequences. Determining their sediment age in conjunction with other information, one can attain considerable information. By specifying existing living creatures ages in these deposits, researchers can obtain sedimentation rates. In the present investigation, four sediment cores from the selected regions in Wetland Lake were taken. Subsequently, making the use of fragments of mollusks shell preserved in sediments, their ages were determined using AMS C14 method. The obtained age was an isotopic age. In order to calibrate the variation to calendar age, Ox Cal V4 software was utilized. Using the relationship between obtained age and depth out of AMS C14, sedimentation rate was determined in wetland. It was also determined that the average sedimentation rate in Anzali Wetland has annually been 0.6 mm following radio carbonic methods.

Keywords: sediments dating, sedimentation rate, isotopic age, AMS C14, Anzali Wetland

INTRODUCTION

Sediments are able to record environmental variations as archives [1]. Determining their age is one of the essential applications to designate sedimentation rate. Determination of sedimentation rate has a pivotal role to specify pollution time and the influxes of various pollutants into the environment. Therefore, it is possible to define sedimentation rate by finding out deposits age. By characterizing sediments ages and pollution in each collected sediments core, it would be possible to specify the variation of pollution with time in sediments. Some methods are demanded to provide exact age–depth models in sediment sequences among which radioactive is the most significant [2]. Age determination by C14 method is one of the methods used in order to designate the age of carbon material having a few years old [3]. This method has been innovated based upon radio carbon amount measurement available in organic specimen and its comparison with new samples.

AMS (Accelerator Mass Spectrometry) method is a method of dating in which minor amount of organic material could reveal reliable response [3]. Mueller and colleagues carried out an experiment making use of C14 for age determination and study the vegetation in Holocene period [4]. Andree and colleagues applied this method in herbal macrofossils to specify lake sediments ages and concluded that using C14 to determine macrofossils ages in lake deposits [5] provided helpful methods for Paleontologist and Paleo–climatologists. Some researchers [6] conducted research using this method in Lake Baikal and concluded that sedimentation rate differed in various regions of the lake. Tylmann and colleagues utilized lead–210 isotope to determine sedimentation rate and recorded erosion changes in lake deposits in Poland [7]. They proved the results obtained out of lead–210 isotope using AMS method.

Radio isotope in Carbon is created as a result of cosmic ray strike to earth atmosphere and its effect on available nitrogen in atmosphere[8]. Next it is blended with oxygen. Then it will be equally distributed in terms of CO with other carbon isotopes in atmosphere and in terrestrial and aquatic environment and live world but with a little changes. C14 experiences an equal and to some extent a constant density in the body of living creatures (due to permanent exchange it has with environment) and peripheral environment. However, disconnecting with environment and lack of replacement and also its consistent disintegration, initial value of C14 reduces after death of the creature [6]. Libby, the founder of this method, assumed the C14 density constant during a time period in the atmosphere. Accordingly he calculated the reduction of available C14 in primitive specimen and determined their ages. Based on this method and following various laboratory work the existing C14 in specimen is converted to CO2, methane and Benzene, and the Beta radiations produced are counted. Subsequently, by using radioactive disintegration equation and carbon14 partial life–cycle (5730) and its comparison with new standard specimen, the age of the sample can be calculated. The obtained age was stated as conventional radiocarbon age (before present time). It indicates the time period passes over the death of given specimen. Zero–time period is considered 1950. It pictures radiocarbon age preceding 1950.

The basis of radiocarbon is associated with the comparison of measured C14 activities in primitive specimen and activities which have been supposed for present time specimen (control specimen activity). If the activities in specimen formation time period bear much more than it had really been supposed to, the obtained age will be very new and vice versa. To calculate ages in laboratories, the specimens are used that their radioactive values equate with wood which has grown in the late 19th century. These radioactive values indicate that these values were protected from the disturbance derived out of human–built effects. In other word, this means that in standard (modern) samples the disturbance of what effects human make, is crossed out [8]. The major goals and purposes of the present paper are to determine:

- The age of sea shells
- The age of sediments
- Sedimentation rate

The Anzali wetland Lake provide an ideal and prime environment using AMS method.

MATERIALS AND METHODS

Anzali international wetland is located in Eastern Longitude of 48° 45' stretches to 49° 42' and Northern latitude of 36°55' stretches to 37°32' in Northern part of Iran in Guilan Province in the southern cast of the Caspian Sea. The problems such as pollution, land usage change and advent of sediments has faced the lagoon with some major environmental issues.

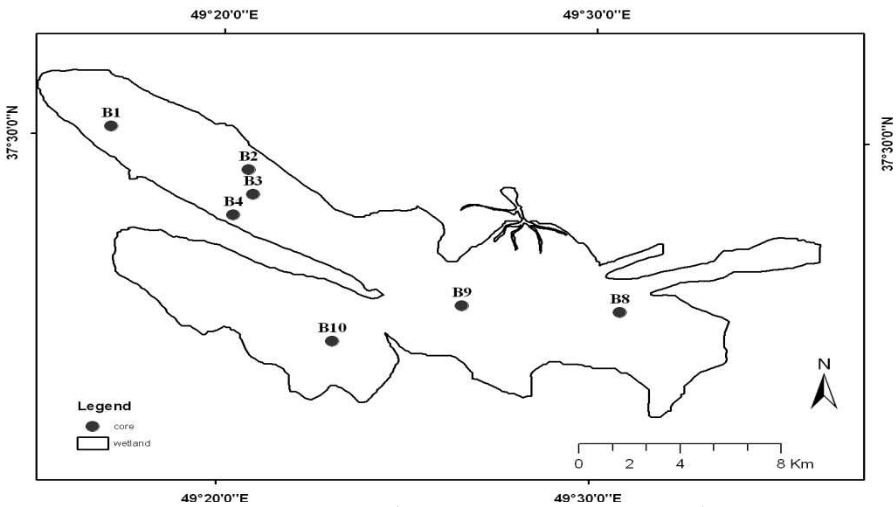

Figure 1. The geographical position of Anzali lagoon and the location of core samplings

In order to determine sedimentation rate, pipis made of PVC was used t collect core samples. The sediments deposited in the Lake in the wetland were sampled in the form of core. Four locations were selected as sampling stations in Lake Wetland (figure 1) in 2007/05/20 and their coordinates were recorded. This wetland is one of the lagoons connected to sea and in windstorm the Caspian Sea overflows via shipping channels in terms of swelling billows and advance to the middle parts of the lake. Therefore, the regions prioritize which always enjoy relative peace, and in fact water experiences less turbulence there. Following the core sampling, the upward and downward directions of PVC pipes was marked using water proof marker. Two ends of the tube were left open for a day and its two sides were longitudinally cut by a saw and the sediment placed in the middle of the pipe was divided in two sections by a sharp steel blade (figure 2).

Using red frame having 30cm length out of larger section, two slopes were taken by fishing cotton and specifying its direction, specimen location and core height position were sent in order to grading, XRD and X Ray. After analyzing sediments, preserved shells were appeared in 80 cm depth in the sea. These shells were transferred to lightener laboratory to determine their ages. Using C14 isotope via AMS (Accelerator Mass Spectrometry) method, one can determine the age of these shells. Shelled horizon was about 8 cm long that determines marine environment .

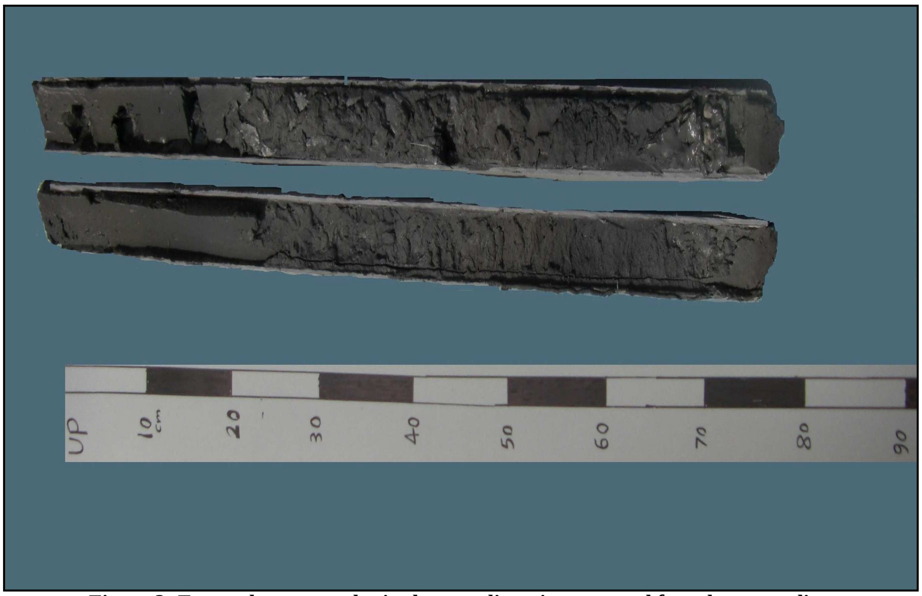

Figure 2: Exposed core samples in the sampling pipe removed from lagoon sediments

RESULTS AND DISCUSSION

Grain size determination (Table 1) indicated that wetland specimens mostly fall in the ranges of silt and sandy mud. The results of XRD also indicated that the most frequent mineral (inorganic material) was quartz. Mineralogy of wetland sediments demonstrated less variation in different places and depth.

Radiography displayed that in most sections, the cores texture were muddy to some extent as what was visible with naked eyes and did not have specific differences in grading.

Table 1. Grading and XRD results

mineral intake Percentage	Feldspar percentage	Calcite percentage	Quartz percentage	Sediment name	specimen	Region/ section
20	-	20	59	Silt	B1suface	Abkenar
29	-	17	52	Mud	B1 deep	
10	10	10	70	Mud	B2suface	
7	7	21	64	Mud	B2deep	
18	9	28	54	Mud	B3	
18	11	11	53	Mud	B4	
9	9	9	72	Sandy mud	B8suface	Sheijan
4	9	19	76	Mud	B8 deep	
7	14	7	71	Mud	B9suface	Hendkhaleh
21	21	14	42	Sandy mud	B9deep	
16	12	20	51	Mud	B10suface	Siahkishem
6	9.6	32	80	Mud	B10 middle	
10	6	20	68	Silt	B10 deep	
29	21	28	80	Maximum		
4	7	32	42	Minimum		
13.46	11.16	15.32	62.46	Average		

The shelled horizon was characterized by more coarse texture and display sandy nature which marked marine environment and environment high energy (figure 3). Shell crust available in core sediments belonged to marine bivalves called *"Glaucum Cerastoderma"* having Holocene–contemporary age. It is one of the most prominent bivalves in the Caspian Sea and salt waters. However it can also live in brackish water and coastal environments [9]. As it was described in methodology, C14 isotopic dating was applied through AMS method for fragment of preserved shell crust which has been observed in Abkenar sediment section in the form of deposit in order to specify sedimentation rate. Following, sedimentation rate can be acquired through the thickness of sediment above [10].

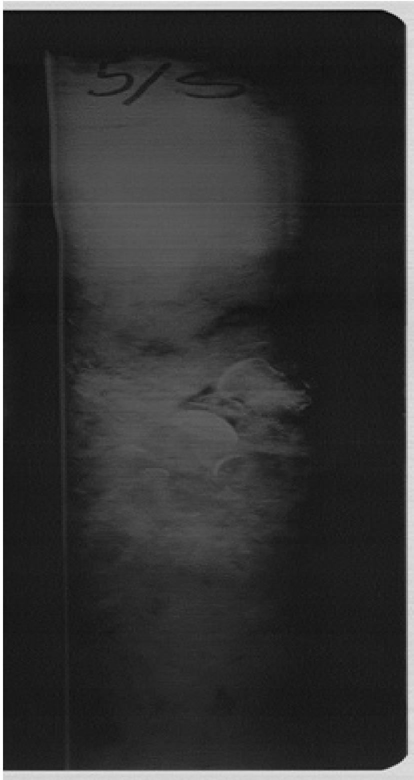

Figure 3. A longitudinal view of selected core radiography

Table 2. Bathymetry results in Anzali wetland

Number	latitude	Longitude	Depth (cm.)	Number	latitude	Longitude	Depth (cm.)
1	361137	4145543	50	15	351616	4152065	180
2	350190	4149651	218	16	350659	4150404	220
3	358490	4145423	180	17	350184	4149656	218
4	348246	4152212	180	18	359102	4145548	120
5	353705	4150001	200	19	358451	4145415	180
6	353882	4148778	210	20	353837	4148771	230
7	353102	4147753	200	21	353051	4147789	170
8	359569	4145179	90	22	357608	4145344	170
9	364022	4149043	600	23	359472	4145468	150
10	367890	4142694	90	24	359547	4144849	50
11	368373	4142930	100	25	360254	4145078	80
12	362134	4143259	130	26	348083	4151155	170
13	357009	4141509	120	27	362630	4142959	140
14	348585	4151794	190	28	362675	4142592	105

The advancement of coastal vegetation communities and shallow water areas toward the center of wetland start with land plants growth and their development opposite to coastal vegetation communities grown on wetland basin (derived out of sedimentation) [11]. This process is called drainage stage of wetland which is clearly observable in many areas of wetland particularly in eastern ponds and in the route of Bahambar River (presence of willow & Alder trees and also other shrubs in everglade edges in both stream sides), with converting Hendkhaleh vegetation communities and western pond regions advancement. Because of these conditions, the water depth in Anzali wetland, once shipping route and sailing area, has been reduced at the present time. Therefore in the present study bathymetry was conducted using PVC graded pipe dipped vertically into the water. In order to achieve that, first the boat was fixed and following the insetion of the pipe in the lake, the water depth was recorded. The results of bathymetry have been recorded according to 28 points of wetland quad regions in table 2. Following this operation, the Bathymetry map was produced using GIS (Geographic Information System) devices (figure 4). The map indicated that the deepest parts of the lake is I Abkenar region in wetland in May 2007, and the shallowest water depth region was in Sheijan.

It is essentially important to investigate and calculate sedimentation rate value in a sedimentary environment such as Anzali wetland according to various reasons. Suspended sediments making water turbid will reduce soluble oxygen in water. They will also fill wetland and help depth reduction and oxygen portability in it.

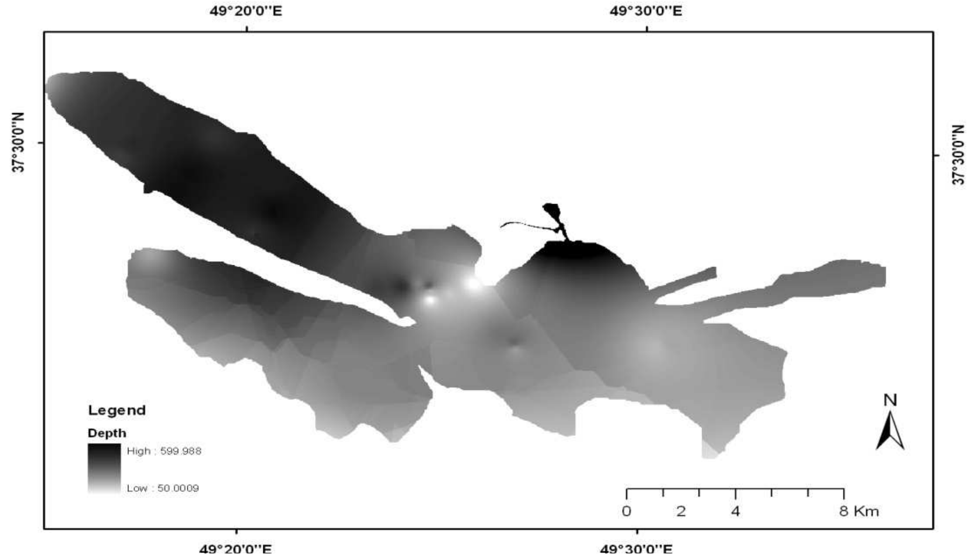

Figure 4. Wetland bathymetry map

Due to variable sedimentation rate in the lake, the nests of bottom–living creatures and other aquatic life collapse. In addition, the gills of fish are also affected by sedimentation. Their eggs are covered by sediments and the disturbance will occur in the nest of the migrant aquatic birds. Following reduction of useful volume of water, maintenance capacity of water in wetland will be reduced and its water overflows and as a result, the agricultural regions will be flooded around the wetland margin. Therefore, it is considered essential to estimate sedimentation rate, sediment entered and carried sediments to the wetland which face deep reduction as a result of sedimentation in recent years. The results of shell ages available in core sediment determined using AMS method and indicated in table 3.

Table 3. Marine shell results

Fraction	Corrected pMC†	Conventional Age	δ 13C (‰)‡
Marine shell, 1.6 mg C	**87.52 ± 0.32**	**1070 ±30BP**	**0.49 ±0.15**

Sediments containing bivalves fossils estimated through AMS method and was equal to **1070 ±30BP** (table 3). However, this figure requires to be calibrated [12]. In order to accomplish that OxCal V4 software has been applied (Ramsey, 2005). With respect to statistical issues, specimens were defined and specified as follows: correlation coefficient 68% (Standard Deviation δ =1), Correlation coefficient 95% (SD δ=2) and correlation coefficient 97.7% (SD δ=3) (figure 5).

After calibrating the determined age by application of C14 method, calendar age ranged from 1240 to1410 years was accepted as a result of highest correlation coefficient. In the above figure, vertical axis is indicative of the sample age before present (BP) time. The horizontal axis showed real calendar age sketched by various deviations on the right.

The curve in red indicate the concentration of measured radiocarbon in **1070 ±30BP**(years before present). On the other hand the blue curve is indicating the radiocarbon value in tree rings and black stripe histogram displayed specimen probable age.

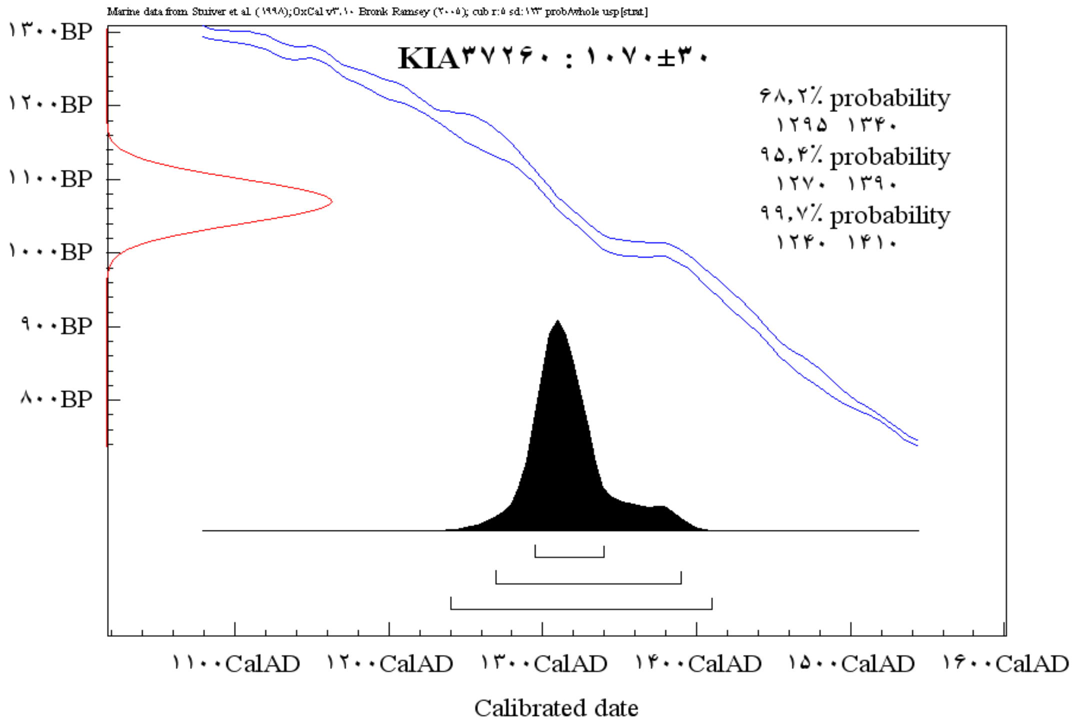

Figure 5. Calibrating a radiocarbon converted to calendar in a specimen

Creating a proportion having sediment height measured from surface to depth, it is possible to calculate sedimentation rate. It is worth mentioning that the height of key layer was equal to 80cm. In Abkenar region, calculated results indicated that sedimentation rate in the wetland lake on average ranged between 0.567 and 0.645 mm. per year and on the average 0.6 mm sediment was annually deposited in Anzali wetland. Subsequent to determination of the sedimentation rate it is possible to state that how old sediments are in various depths. For instance, sediments deposited at the surface (0), 50, 200, 100, and 500mm are 0, 82, 165, 331, and 828 years old, respectively [13]. Making use of available bivalves shells in sediment cores from the Alikes lagoon, researchers have determined wetland sediments rates. The studies on sedimentation rate and its variations have been investigated by Japan International Cooperation Agency in Anzali Wetland in 2005 [14]. The results indicated that sedimentation rate varied throughout the wetland between 0 to 6 mm per year. Therefore, the 0.6 mm. which is obtained as an average rate per year belonged to Abkenar region in this investigation in which a region experienced lower sediment entry. Thus, the lower sedimentation rate in this region appeared to be natural compared to other regions.

CONCLUSION

Sedimentation rate in in Anzali Wetland using C14 method was determined to be 0.6 mm per year. Based on the present investigation, it is concluded that applying C14 method for shells preserved in the sediments can be a remarkable and useful tool which was directly related to C14 derived out of other resources including tree rings and frozen cores [5]. As a result, it can specify the time of pollutants entry and consequently sediment contamination which were part of wetland ecosystem. It will assist in determining the density of pollutants including heavy metals deposited in various depths. It is also suggested that in wetland and lake environments, special attention should be given to preserved shells to determine their age by C14 method. Otherwise there will be the probability of making mistake in the results of determining the ages of strata. It is likely that the shells to be replaced in differing strata as a result of various water currents and turbulence and do not belong to the time of stratum depositing. It is recommended that the numbers of cores increase to compare the differences of sedimentation rate in wetland various regions. Other suggestion will be integrating age determination and pollution results to rebuild the condition of pollution in this environment and similar areas.

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