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Determine Anzali lagoon sediment age based on Cesium-137

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Abstract

From descending sedimentation rate viewpoint, accumulation of sediments in Anzali lagoon may be accompanies with rising water level in Anzali lagoon and descending the depth of the lagoon. Thus getting knowledge about the rate and the degree of sedimentation in lagoon can provide planners with useful approaches. Cesium-137 is an artificial Radionuclide with Gamma rays and half- life of 2/30 years which is produced as a by-product resulting from nuclear experiments of previous decades and released in stratosphere. Considering the high-powered of this approach in accuracy of assessment and easiness of data collecting, it has been used in surveying the age of sedimentation in Anzali lagoon. In this research, sampling is done in three spots, to the depth of 4 meters, with a core drilling machine. Grading, moisture and plastic limit of samples are measured in the laboratory. Then 10 samples in different levels from three boreholes (BH) are taken for Cesium 137experiment and are sent to Atomic Energy Organization laboratory. As well, MPSIAC model is used to calculate the degree of sedimentation empirically. Results of the grading show that samples of sediments are mostly fine-grade in different layers of the earth. An overview shows that soil layers at the first BH is silt with low plastic attributes. In the second BH, soil layers from the surface to the depth of three meters is silt with low plastic attributes and from the depth of three or four meters is silt with sand and low plastic attributes. Soil layers in the BH3, from the surface to the depth of three meters is silt with low plastic attributes and from the depth of 3 to 4 is silt with sand and low plastic attributes. Age measurement of the different layers shows that most Cesium is in the depth of 2.4-2.7 considering mentioned depth and time interval of the incidence, density of the sedimentation equals to 8.5 meters per year.

Key words: Anzali lagoon, Sedimentation Rate, Cesium Age, Gamma Spectrometer, Sampler.

1-Introduction

Lagoons are mossy lowlands, fenny, artificial basin, having slack or running water permanently or temporarily, soft or seawater and areas with sea water in which the depth in ebb tide is not more than 6 meters. Based on lagoons convention of the country in 1984, lagoon is a God-given nature, its soil is saturated in the process of infrastructure based on surface and ground water and is constituted during a suitable period of time as well as usual and natural circumstances and have biological sequence. This ecosystem consists of special herbs and animals adjusting ecologic circumstances such as (backwater, bog, lake, and dam). Lagoons ecologically, economically, aesthetically and from promenade viewpoint have undeniable values for human, animal and herbal societies. (Ranjbar, 2013)

Lagoons and water ecosystems are valuable asset that adjusting peripheral groundwater, controlling floodwater, preventing from advancing seawater, equalizing microclimate, haunting, fishing, matting, all depend on logical protecting of them. Protecting these complicated ecologic systems and benefitting from countless economic, promenade, genetic and…resources are only depend on studying and precise knowledge of each lagoon. In spite of the efforts done for protecting and directing lagoons, threats such as water resources limitation, lagoons competition with different uses to utilize water resources, change the use of the lands in catchment areas, changing usage in margin and inside the lagoons, discharge of city, industrial and agricultural sewage without suitable purification, high level of sediments in surface water, protracted drought, lack of planning and suitable managing of the lagoons confront them with serious menace. (Protecting plan of Iran lagoons, 2014)

Sediments have always considered as an active resource of water pollution. Sediments record environmental changes like an archive (Alexander, 1993) and detecting their age to determine the rate of the sedimentation, is their important usage. Entering different contaminants in recent years have caused the rate of sedimentation become vital for determining the time of pollution. (Khosheghbal & Ghazban, 2011) Since sedimentation rate can be determined by knowing the age of the sediments and with knowing the degree of pollution in each part of sediment, polluting time modifications can be assessed. Having enough knowledge about the rate of sedimentation is applicable for dredging program. In navigation channels and other areas which are dredging continuously, sedimentation rate can be calculated through assessing the date of depth periods (Jeter, 2000).

Determining the age is used in assessing whether sediments displaced or declined. Furthermore soil erosion and sedimentation are basic problems in the country and knowing their quantity in different circumstances is helpful for better knowledge of condition and planning in protecting and utilizing. (Hosseinalizadeh & Alipour, 2013). Determining the age and assessing sedimentation model entails stable water level in different parts of a lagoon since investigating lake`s water level vibrations to protect them has found a special place in recent years among countries, nations and districts. One of the most applicable techniques to determine the age of the sediments in lakes and lagoons is using falling radionuclide. Cesium is an alkali element with chemical features similar to sodium, potassium and other group I elements in periodic table (Asadi et al,2012) Cesium-137 is an artificial radionuclide with physical half-life of 2/30 per year, the result of testing nuclear weapons in atmosphere, which had been produced and sent to atmosphere since 1950 to 1962 and then fell down the earth (Sharmed et al,2013). After nuclear disaster of Chernobyl reactor in 1986 cesium-137 increased on the earth. (Dong et al. 2013) Thus whenever we face with increasing Cesium-137 radioactivity, attribute it to 1986 and age of the sedimentation is determined. (Panayotou, 2004) Cesium-137 is the most usual falling radionuclide in soil which is used in different environmental and agricultural circumstances around the world. The spatial distribution of its fall is determined by nuclear experiments situation, circular pattern transferring stratosphere, rate of rain per year and shows distinct latitude zoning. Universal pattern of Cesium-137 fallout is as a result of nuclear weaponry and shows cesium-137 changes which depend on latitude. (Agudo, 1998). There is no natural resource for cesium-137 and it has been produced during the nuclear fission and its presence refers to nuclear experiments and releasing from nuclear reactors. (Walling et al, 1986) Measuring cesium-137 function is usually done by Gamma spectrometry using ultrapure germanium detector in energy range.(Hosseinalizadeh&Alipour,2013) Accompanying validity measurement, sediments age measuring method using cesium-137, it is considered that historical events influencing the degree of cesium (nuclear events) should be carved in that isotope`s activity curves with sediments` vertical profile. (Szmytkiewicz and Zalewska, 2014) Measuring lead (Pb)210 based on gamma spectrometry is difficult and time consuming ((Hosseinalizadeh&Alipour,2013) Other methods for determining Pb 210 are radionuclide chemical analysis,α and β spectrometry and counting with liquid needle (Villa et al, 2007) have more precise results (Jia and Torri, 2007) although these methods are expensive and need more laboratory labor. Another method is using plasma mass spectrometry which is used for measuring low levels of Pb210. (Lariviere et al., 2005)

Anzali lagoon in south margin of Khazar Sea (Olah, 1990) with soft water and suitable ecosystem circumstances for fish farming is very important. In recent years unfortunately because of excessive amount of contamination resulting from city, agricultural and industrial sewage this lagoon is facing with serious danger of pollution to heavy metals. Invasion of lagoon border, using it for agriculture, evacuation of polluted water, industrial, agricultural and fish farming pools sewage in the lagoon, illegal haunting, entering non-indigenous specious, increasing sediments and erosion of catchment areas of the Lagoon, entering high sediment load and garbage are all threats for the lagoon. (Ranjbar, 2013).

These dangers put Anzali lagoon in red state in terms of Ramsar Convention. Investigating and calculating sedimentation in a sedimentary situation like Anzali lagoon are important for different reasons. Suspended sediments make opacity in water, reduce oxygen in it also with filling lagoon, and reduces the depth and oxygen carrying. Bottom dwellers habitat and other sea animals destroy as a result of sedimentation and fish gills suffer from sediments, their spawns cover with sediments and migratory bird habitat will be disordered. As a result of reducing useful magnitude, lagoon storage capacity reduces and water overflows and agricultural lands around the lagoon waterlog (Zarekhosheghbal& Ghazban, 2011).

Purpose of the present research is investigating the age of sediments in Anzali lagoon to determine entered and carried sediments in lagoon. Based on what researchers have done up to now and considering Iran situation in central Asia with almost 80 Becquerel per square centimeters, Iran is in normal limit to use this radionuclide which make necessity of using this radioisotope in determining the age of Anzali lagoon sediments undeniable. Purpose of this research is investigating usefulness of MPSIAC model in the degree of sediments and comparing age measurement method with experimental method to recognize the degree of producing sediment in Anzali lagoon.

1.1 Research background

Local measurements from sedimentation rate in Venice lagoon in Italy shows that the rate of sedimentation is considerably affected by morphology of the district.(Amos et al,2004) Carbon14 is used for determining the age and investigating the reason of modifying herbal covering in last holocene period.(Mueller et al, 2009) In a research in China, time and location modification in the rate of sedimentation during recent 150 years in Tangra Yumco lake and tank effects are assessed by the age of Carbon 14 determined from sedimentation and herbal fragment. Results show that determined ages from herbal fragments are fundamentally younger than determined degree of sediment mass.(Wang et al,2015)Isotope Pb210 is used for determining sedimentation rate and changes in recorded erosion in sediments of a lake in Poland and with using AMS method in age measurement, obtained results from isotope confirmed pb(plumbum)210.(Tylmann et al, 2009) In investigating sedimentation rate and sediments mass in Baltic sea (clean gulf), sediment layers age are measured with pb210 method (fixed supply rate) in which deepest layers are 1900 years old (Szmytkiewicz and Zalewska, 2014) Brawn et al (1981) have distributed results of their research using cesium-137 as an erosion index. Results have represented a considerable modification in the soil of planting farms and sediments absorb cesium-137 rapidly. Using cesium-137 method in Sri Lanka has showed that this method has a high ability in calculating the degree of erosion in lands with different space and has different application. (Chamia et al, 2010) A research is done in Algerian coasts in 1994 to 2004 with the aim of investigating sediments mass in IAEA district. To do this pb210 and cesium-137 in sediments from core drilling machines and with direct counting of spectrometry gamma device are read. Accuracy of the quantitative researches depends on the earthly amount of these radioisotopes. As well the degree of the 210 element emission is 45 kev gamma per sample. In order to estimate the degree of sedimentation using pb210 and cesium-137 concentration profile and with using CRS model, sedimentation expansion shows 20 to 27mm per year. (Noureddin, 2010) Sedimentation rate in an area with black soil in north of China called Hebei district is assessed from 1977 to2007using distribution of cesium-137 and pb210. Results has shown that average sedimentation rate for the whole period was 22.6mm per year. Furthermore, rain is one of the main reasons for erosion and sedimentation in this district. (Dong et al, 2013)

In a research with the aim of investigating degree of erosion and soil loss in the country, cesium-137 was used. Comparing erosion degree and soil loss in different application showed that forest lands had tiniest amount and after that pasture lands and dry farming in a row. Soil loss in marl land pasture had the most degree comparing to the other pastures. As well, the most degree of soil erosion and loss was in 1.5 to 12 % slope. (Khajavi et al. 2016) Ebrahimi et al (2003) declared 3 ton per hectare erosion in soil erosion studies using cesium-137 in west of tea farm of Gilan province. In the study in south coast of Khazar sea (near Langroud city) a core with the length of 142cm was taken. Determining the age of the sediment based on measuring pb210 and cesium-137 method was done and sedimentation rate of 0.9 cm per year was reported. Moreover, the most radioactivity of cesium-137was in the depth of 20 to 25 cm. (Sharmed et al, 2013)

In investigating Khazar sea coastline in late Quaternary, geomorphology, sediment and fossil evidence in Gorgan bay district was used. To determine the age, five sample fossil of mussel based on C14 method was sent to Japan laboratory and the age was determined. Analyzing the result of the age measurement and field studies, identified existence of 5 sea terrace was made 461,496,541,594 and 2438 years ago (Emadoddin et al, 2015). Sartaj et al(2012) have monthly reported for six months that among metals, zinc has the most degree in sediments and density of heavy metals in sediments inside the lagoon is less than other stations with investigating distribution procedure and heavy metal mass in Anzali lagoon sediments in 15 stations. Aminiranjbar(1993) investigated the degree of heavy metal mass in superficial sediments of Anzali lagoon. In this research degree of zinc, copper, nickel, lead and cadmium in superficial sediments of 11 stations was determined. Four different methods were used to determine the degree of mentioned metals in a sample and digestion method with the mixture of nitric acid and chloridric acid which had higher impacts, was chosen as the most suitable method. Results showed that there was not a meaningful statistical difference between different seasons in metal density. In a research the degree of erosion in a humid climate (Mazandaran and Gilan province) is most comparable to the other climates. It sounds that additional erosion obtained from cesium-137 method in these areas, is because of the proximity of understudy places to Chernobyl disaster in relation to other places and efficacy of precipitation in these lands. Based on the investigations, effect of this disaster on south and north hemisphere and also other precipitation is different and more important (Khajavi et al, 2016).

2. Materials and Methods

Understudy area called Anzali lagoon is located in Gilan province. Anzali lagoon is located in southern margin of Khazar Sea between 37 degree and 25 min to 37 degree and 32 min in north and also 49 degree circuit and 15 min to 49 degree and 36 min in west. Anzali lagoon as an aqueous environment which is ecologically very important because of animal and herbal diversity and is always subjected to heavy metals contamination. (Vesalinaseh et al, 2013) In catchment area of the lagoon with 7403 kilometers width (Ghazban & Khosheghbal, 2012) many rivers flow, among them 10 important rivers with superior discharging than others are main entrance rivers to the lagoon. (Figure1-3) Anzali lagoon basin has respectively maximum and minimum altitude of 3014 and -26 meters from sea level. Average amount of lagoon fall is 1280 mm while evaporation is about 980 mm. Anzali lagoon immediate area is 168 square kilometers (Ranjbar, 2013). Anzali lagoon consists of four section, west (Abkenar), east (Shijan), central (Hendkhale) and south(Siakeshim). This lagoon is limited to Khazar Sea from the north, Somesara and part of Rasht from south, Pirbazar from east and from west to Kapourchal and Abkenar. Its average length in east-west direction is about 30 km and its average width in north-south direction is about 3 km. (Ghazban & Khosheghbal, 2012).

Table 1 Dubai long-term average (2003-2012) for 10 important rivers in Anzali lagoon area

River	Dubai yearly average sqm/s	River	Dubai yearly average sqm/s
Ibrahim shrine	4.03	Pasikhan	18.59
Khalkaei	4/45	Pibazar	8/94
Siahmazegi	4/07	Siahroud	4/57
Kolsar	6/41	Shakhazar	10/2
Morghak	3/33	Masule	3/78

Based on geomorphological studies, Anzali lagoon age is geologically recognized young and imagined that it has been formed through some steps. The most essential possibility of its existence is related to declining Khazar sea level in 13th century and other lagoons blockage because of Siahdarvishan, Pirbzar and Pasikhan rivers blockage. Zoning category of Anzali lagoon district is located in Gorgan-Rash zone from Alborz Mountain. This basin which is part of northern Alborz sedimentation in middle and upper Jurassic based on sedimentation viewpoint will be cleared with lacking clear stratigraphy in high Bajocian and Bathonian. In second period, micaceous green schist, schist, Jurassic sandstones protrusion in Pasikhan valley as well as calcic, calcic-marl and marl calcic which are in Masule River in Cretaceous period can be mentioned. One of the most important characteristics of district index is thickness of damaged and shallow sediments in Neogene-Quaternary which is mainly the result of aquatic and mechanical Alborz formation (Ranjbar, 2013).

Recent sediments can be divided into three types based on the resource:

1. Costal progressive and retrogressive sediments of Khazar Sea which are visible from plain to foothills as clay and sludge formations.
2. Sediments erosion of Alborz formations which are seen in foothill and southern part of the plain as large pieces, pebble and sandy.
3. River sediments series continues in rivers old path from southern to northern valleys.

Considering the situation of lagoon in southern part of Khazar Sea, this lagoon is always threatened by contaminant from different resources and mostly affected by human, industrial, navigation, farming activities, Khazar petroleum operation and tourism industry (Khosheghbal et al, 2012). Advancing coastal herbs and shallow part of the lagoon to the central which cause the lagoon to be dried as a result of herbs growth are seen in most part of the lagoon specially in east pools and Bahnamir river path (sallow and alder trees and other kinds of bushes in reedy margin of the both sides of the water) with modifying herbal communities of Hendkhale and advancing western pools` lands is clearly visible. On the other hand, vegetation and forests in upper areas are destroyed and cause many sediments enter the lagoon and intensively decline the depth of lagoon. In order to measure sedimentation design and its age measurement, core drilling operation and sampling from the lagoon were chosen to determine the age of the sediments.

In using falling radionuclide to determine the sediment and transfer, key areas are necessary, determine sample and method of sampling is highly important (Sutherland, 1996). Representativeness of a sample and variability of sampling in reference area should be considered (Owens & Walling, 1996) and repetitive or multiplex samples should be gathered in order to availability of cesium (Zapata, 2002). To select place and number of sampling station with modeling from standard references and considering the number and situation of sediment entrance resource, stations is marked on the map.

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Then with doing field study and impose limitations such as accessibility and sampling considering marshy parts of the lagoon, 3 stations in southern parts of it (Pirbazar-Chakuvar village) are selected (figure1). Places are identified on the map with studying satellite images and field observations. To sedimentology of the area and soil layers characteristics in understudy district, sampling is done on September 2017 in three identified places. Sediment sampling by core drilling machine with metal pipe and inside diameter of 2 inches as well as 2 inches hammer with 30 inches handle to hit and hydraulic jack to take out core are taken (figure 1 to 3). To do this with drilling 3 bore hole of 4 meter depth and continuous coring method samples are taken. Samples of sediments are put in special boxes to be fixed enough and prevent from moving or disordering the sediments.

Figure1.Sampling from part 1(BH1)

Figure 2. Sampling from part 2(BH2, BH3)

2.1 Physical Experiments on Samples

In order to identify different physical and mechanical characteristics of soil in different layers, mechanical tests such as direct cut and physical tests like relative density, humidity percentage and grading is done. Grading experiment is done by a number of sieves with different sizes based on ASTM standard and determining distribution of fine-grained size is accomplished with hygrometry method. Grading test and hygrometry is done for double on samples which are mixture of fine-grained and coarse-grained materials. Liquid limit and plastic limit of pieces smaller than 0.425 mm (sifting through sieve number40) are determined by ASTM D43 standard method. Liquid limit is conventionally defined as a moisture percent in which there are mass of grooves by standard grooving, inside the device standard liquid limit as a result of 25 hit in the length of 12.7mm reach together. Plastic limit is conventionally defined as a moisture percent in which a sample of silt or clay is divided into pieces while robbing to make a 3.2 mm diameter lint. Furthermore, some samples natural moisture percent gathered from different depths, are determined based on standard method of ASTM D2216. Moreover, before delivering sample to laboratory obtained cores are investigated and its apparent characteristics are analyzed through geological viewpoint. It should be mentioned that color determination is done based on its apparent characteristics and journal no.153 irrigation and canalization, otherwise, Munsell color chart is used for sediments color determination.

2.2 Preparing Samples for Cesium-137 Experiment

The most basic method for preparing sediments is micro-sampling. Since radionuclide experiments are not basically necessary for all obtained cores. Furthermore, considering high depth of cores, experiment cost will be increased. So a basic principle of sample preparing is core column division to small pieces of centimeters which can be a good representative of whole core and considering archive characteristic of sediments sampling is done just from special parts without wasting money, time and human resources. In other word, sampling from core is important since by determining the density of existing isotopes and their exact counting, the way of their distribution and sediments different profiles can be investigated and determine sedimentation rate and sedimentation mass rate. In this regard, selecting core cutting range has strong effect on cost and accuracy of the task.

To select sampling layers, first (BH-1) which dig far from Khalkaei river, is fine-sand and below it to the depth of 1 meter there is sandy silt and the rest are silt and clayey silt. In the depth of 2 to 2.2 m it is sample less which probably consist of very fine-sand made sampling impossible. To measure samples age, below the depth of 2.25 to 4 m which get no impression of river floods can be considered suitable index for measuring sedimentation time with 1.75 m (horizon of 2.25 to 4m) thickness. Sedimentation horizons between the surface and depth of 2.25 m are not advised because of their impression of yearly floods. Hence, a sample from the depth of 1.6 to 1.9 m, a sample from the depth of 2.4 to 2.7m, a sample from the depth of 2.9 to 3.3m and a sample from the depth of 3.5 to 4m are taken.

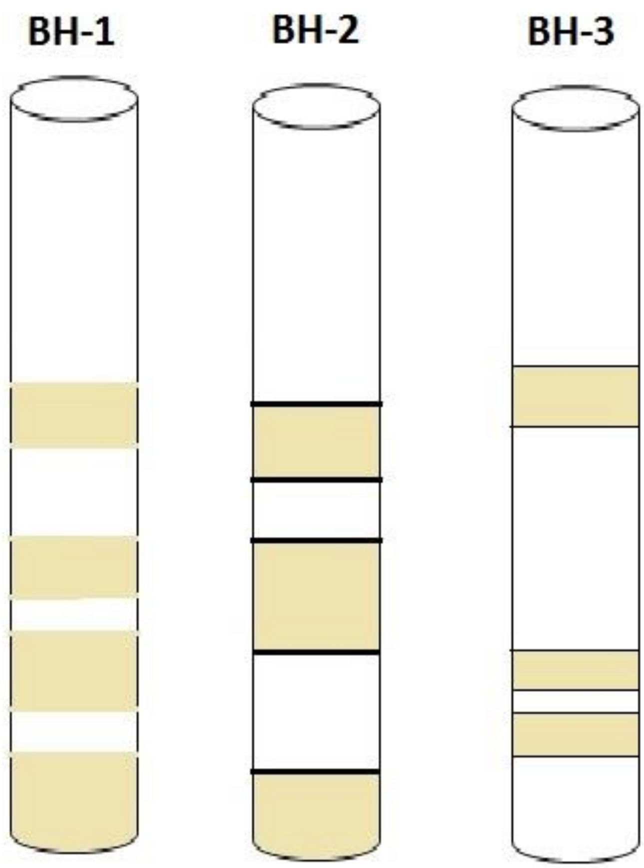

Figure 6.3 samples taken from core in different thickness

2.3 MPSIAC Model Application

To apply MPSIAC model it is necessary that catchment area understudy divide into hydrologic units or homogenous geomorphologic task units. After dividing catchment area to mentioned units, nine factors score in each task unite will be calculated. Total of these scores will identify related score to sedimentation and erosion rate in each unit (Davari et al, 2006). After determining sedimentation degree and erosion rate to determine the degree of sediment in MPSIAC model (1-3) relation is used (Clark, 1999).

$$Q_s = 38.77\ e^{0.0353R} \qquad (1\text{-}3)$$

In which Qs is the degree of yearly sediment (M^3 per KM^2) and R is sedimentation rate which equals to nine factors total scores. To investigate the impression of effective factors on erosion occurance and the degree of sedimentation, geological layers parameters, Anzali area slope, altitude toward sea level, distance from river and road, rain, ice and snow melting effect and land usage on environment geographical information system is numeral. Specific layers of land use by satellite images in 2015, geological layers by map with scale, slopes path and their altitude by map topography and rain data by using aerology information are prepared.

Data used to perform MPSIAC model were consisted of:

1. Numeral topography map from Anzali area with scale…
2. Topography map from Anzali area with scale…
3. Landset satellite numeral data related to Anzali area
4. Raining data in Anzali area available stations
5. Area soil map with scale…
6. Area geological map with scale…

At first available maps are arranged based on model format and all maps are registered on each other. Then, numeral map are provided from different data. After that, different factors weigh in MPSIAC model are identified and total degree of effective factors for each area are calculated. Finally, degree of erosion and sediment are identified. All maps needed for model, after numerated are changed from liner structure to web structure with 50 to 50 m cells. By using created information layers and based on each model structure, necessary processes are produced and initial information layers of models (producing sediment map) are prepared. Task different phases are as below:

1. Mentioned maps preparation
2. Numerated maps with GIS
3. Dividing catchment basin and identifying task unites
4. Determining superficial geological factor credit in MPSIAC model through $Y_1=X_1$ relation in which Y_1 is geological factor and X_1 is superficial geological erosion index.
5. Determining soil factor credit in model in each task unit through this relation $X_2=16.67K$ in which X_2 is soil sedimentation factor credit and K is soil erosion factor in universal soil erosion formula.
6. Determining whether credit in each task units through this relation $Y_3=0.2X_3$ in which Y_3 is weather factor credit and X_3 is 6 hours rain fall degree with 2years turnover on mm scale.
7. Determining sewage and running water credit through this relation $X_4=0.2(0.03+50QP)=0.006R+10QP$
8. Determining ups and downs factor in each task units in the model through $X_5=0.33S$ in which S is average slope of the area based on percent
9. Determining covering factor credit in the model through $X_6=0.2PB$ in which PB refers to bare land percentage.

10. Determining credit and using lands in the model through X_7=20-0.2PB in which PB refers to cover crest based on percent.
11. Determining factor credit current erosion in the model through X_8=0.25SSF in which SSF is soil surface factor credit.
12. Determining river erosion credit in model through X_9=1.67SSF.g in which SSF.g is final score of gallery erosion in soil superficial factor in BLM method.
13. Nine factors credit in each task unit multiply its measurement relation and with sum of the obtained credits, whole area sedimentation rate(R) are obtained and degree of yearly sedimentation is determined by (2-3) relation.

$$Q_s = 38.77\, e^{0.0353R} \qquad (2\text{-}3)$$

3. Results

After physical experiments, type of soil in different depth of BH is determined. Grading results show that land layers sediment samples are mainly fine-grade. Scanning shows that soil layers in first bore hole (BH-1) from surface to the depth of 4m is silt with slight plasticity. In second bore hole (BH-2) soil layers from surface to the depth of 3m are silt with slight plasticity and from 3 to 4m is sandy silt with slight plasticity. Soil layers in third bore hole (BH-3) from surface to the depth of 3m are soil with slight plasticity and from 3 to 4m are sandy silt with slight elasticity. Generally, silt is the main part of the soil in layers and soil texture in different parts are mainly silty clay. Most of these sediments are depositions created from Khazar sea waves and displaced sediments as a result of superior floods. Results related to the soil moisture percent in different depth of each bore hole are shown in (1-4) table. Increasing the depth make soil moisture more in soil layers, hydrostatic surface in lower layers, make moisture stronger.

Table 4-1 results for soil moisture % for different depth of bore hole BH-1,BH-2 and BH-3

BH-1		BH-2		BH-3	
Humidity %	Depth(m)	Humidity %	Depth(m)	Humidity %	Depth(m)
41.6	1	52/74	1	52.28	1
45.7	2	69/24	2	45.00	2
47.3	3	86/49	3	74.26	3
45.0	4	88/00	4	99.04	4

Atterberg limit experiment results for different depths of each bore hole are shown in table (2-4). Liquid limit is moisture percent corresponding to behavior modification between liquid and plastic condition of silt or clay. Average liquid limit in different bore hole is 45%. Plastic limit is moisture percent corresponding to behavior modification between plastic and semisolid condition of silt or clay. Plastic limit in different bore holes varies between 29% to 38%.

Shrinkage limit is moisture percent in which modifying a silt or clay semisolid conditions to solid occurs. Shrinkage limit can also be defined as a moisture percent that lower than those moisture never cause reducing soil mass. Shrinkage limit percent modifies between 17 to 23% which is almost half of the liquid limit.

Table 4-2 Atterberg limit experiment results for different depths of BH-1, BH-2 and BH-3

BH-1				BH-2				H-3			
SL	PL	LL	Depth(m)	SL	PL	LL	Depth(m)	SL	PL	LL	Depth(m)
21.7	38.8	45.7	2	N.P	N.P	N.P	1	22.3	36.0	45.0	2
19.6	32.8	45.0	3	20/4	33/9	48/7	4	17.8	29.7	46.5	4

NP: none plastic soil
LL: liquid limit
PL: plastic limit
SL: shrinkage limit
A summary of sediments grading in BH-1 are shown in table3-4.
Most percent of particles appertain to silt. Clay percent is also considerable in core texture.

Table 4-3 sediments grading- Core 1(BH-1)

Depth (m)	**Clay %**	**Silt %**	**Fine sand %**	**Medium sand %**	**Coarse sand %**	**Fine gravel %**	**Coarse gravel %**
2	33.4	50.8	7.6	5.8	2.8	0	0
4	40.9	45.0	7.1	6.6	0.7	0	0

A summary of core sediments grading of BH-2 are shown in table 4- 4. In upper layer of this core silt and clay are dominant but in lower layer in the depth of 2 to 3m silt ad fine-sand have the most percent of the sediment texture.
Table 4-4 sediments grading – core2 (BH2)

Depth (m)	**Clay %**	**Silt %**	**Fine sand**	**Medium sand**	**Coarse sand**	**Fine gravel**	**Coarse gravel**

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			%	%	%	%	%
1	37.7	45.8	4.4	7.1	0.4	1.0	0
3	11.1	40.0	30.9	11.2	5.9	1.0	0

A summary of core sediments grading of BH-3 are shown in table 4- 5. Silt in this BH is more than other elements. Of course in lower depth, silt is reduced and clay is increased. Silt sedimentary can be because of its increasing in lower level.

Table 4-5 sediments grading- core3 (BH3)

Depth (m)	Clay %	Silt %	Fine sand %	Medium sand %	Coarse sand %	Fine gravel %	Coarse gravel %
1	27.1	66.2	2.4	1.4	0.3	0	0
3	31.2	47.9	5.3	7.0	6.1	2.7	0

2-4 sediments layering

In the following parts results related to apparent color and different layers texture are separately presented. Furthermore, sampling sections in different layers is also presented.

BH-1

Soil layers in above BH are from the surface to the depth of 4m with low mark (ML) plasticity. Dominant color in this BH is green and just in top layer it is blue. Soil texture in top layer is sandy silt. But in lower layers is clayey silt which shows clay sediment in these layers.

<table>
<tr><th colspan="3">BH-1</th><th colspan="3">X= 352254.05</th><th colspan="3">Y= 4143541.70</th></tr>
<tr><th>Layers color</th><th>depth (m)</th><th>layer</th><th>sample</th><th>texture</th><th>moisture (%)</th><th>LL</th><th>PL</th></tr>
<tr><td>blue</td><td rowspan="3">0-1</td><td rowspan="5">Low plasticity silt (ML)</td><td rowspan="3">BH1-1</td><td>Silty sand</td><td rowspan="3">41/6</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>green</td><td>Sandy silt</td></tr>
<tr><td>green</td><td>Clay silt with a few sand</td></tr>
<tr><td>green</td><td>1-2</td><td>BH1-2</td><td>Clay silt with vegetative remains</td><td>45/7</td><td>45/7</td><td>38/8</td></tr>
<tr><td></td><td>2-3</td><td>BH1-3</td><td>Sample less</td><td>47/3</td><td></td><td></td></tr>
</table>

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green				Clay silt			
green	3-4		BH1-4	Sticky silt	45/0	45/0	32/8
Sample for age Determination Experiments			**Plasticity limit: PL , Liquid limit: LL**				

BH-2

Soil layers in this BH are as follow:

- From surface to 3 m depth with low plasticity silt ML
- From 3 to 4m sandy silt with low plasticity silt ML

  Sediment color in different layers of this BH is different as, to 2m layer, green is dominant color but in lower layers green and black.

BH-2			X= 352444.00			Y= 4143848.00	
Layers color	**depth (m)**	**layer**	**sample**	**texture**	**moisture (%)**	LL	PL
brown brown Light brown	0-1	(ML) Silt with low plasticity	BH2-1	Coarse-clay Silty clay Clayey silt	59/7	N.P	N.P
Light green Light brown green	1-2		BH2-2	Silt & clay with little sand Silty clay Fine-sand Silt- clay	69/2		
Light brown	2-3		BH2-3	Clayey silt Silty Fine-sand Silt& Fine-sand	86/5		
green black	3-4	Sandy silt with low plasticity (ML)	BH2-4	Fine-sand Silt & sand with vegetative element Fine-sand	88/0	48/7	33/9
Sample for age Measuring Experiments			none-plastic :N.P , plastic limit **:PL** , liquid limit **:LL**				

BH-3

Soil layers in this BH are as follow:

- From the surface to 3m depth silt with low plasticity ML
- From 3 to 4m depth sandy silt with low plasticity ML

In this BH most sample color are light blue. Soil texture in most layers is clayey silt. Moisture percent in lower layers (3-4m), shows full saturation which implies high water level in this part.

BH-3			X= 352688.11			Y= 4143809.84	
Layers color	**depth (m)**	**layer**	**sample**	**texture**	**moisture (%)**	LL	PL
Blue prone to grey	0-1	(ML) Silt with low plasticity	BH3-1	Clayey silt	52/3		
				very fine silt& sand			
	1-2		BH3-2	Sample less	45/0	45/0	36/0
light blue to grey				Clayey silt			
				Sample less			
Grey to light blue	2-3		BH3-3	Clayey silt with organic materials	74/3	46/5	29/7
				Sample less			
light blue	3-4	Clayey silt with low plasticity	BH3-4	Silty clay	99/0		
dark blue				Clayey silt			
Light blue				Clayey silt			
				Sample less			
Sample for age Measuring Experiments			LL: liquid limit, PL: plastic limit, Gs: special weight, -e:hollowness, -n: porosity				

Cesium-137 density in different depths is related to different presented parts. Increasing trend is shown to 2.7m depth and decreasing trend is less than that. Most cesium is identified in 2.4 to 2.7m with 9.3 becquerel per kg. If this depth attributes to the year of Chernobyl disaster (1986) and land surface to the year of sampling, time interval between two incidents will be 30 years. Considering foresaid layer core, it can be concluded that, about 255cm sediments has been added during 30 years which calculated 8.5m sedimentation rate per year. Sodium modification trend attributes to depth in BH-1 and BH-2are relatively alike but BH-3 shows different trend. Cesium distribution and clay percent in different depths are presented in table (4-5). Clay particles strongly preserve cesium on their top and prevent from their move in soil (McCallan et al,1980). As well, in an intact soil with increasing soil depth, generally clay percent will increase as a result of leaching. In different cores with increasing depth, clay increases except in 2.4-3 and 3.6-4m of core number 2 which has different trend. Clay growth is aligned with cesium growth. Thus erosion measurement and sedimentation in soils with heavy texture declares good results.

Table 4-5 Cesium-137 density in different depths

Sample code	Cesium 137 (bicquerel per kg)	Soil depth (m)	Sample code
27/1	2/5 ± 0/16	1/5-1/8	BH-3
33/4	4/1 ± 0/23	1/6-1/9	BH-1
37/7	4/5 ± 0/27	1/7-2/0	BH-2
34/2	9/3 ± 0/22	2/4-2/7	BH-1
11/1	4/2 ± 0/23	2/4-3/0	BH-2
33/4	3/8 ± 0/23	2/9-3/3	BH-1
34/2	<4 ± -	3/0-3/2	BH-3
36/6	4/1 ± 0/27	3/3-3/5	BH-3
40/9	1/0 ± 0/11	3/5-4/0	BH-1
10/6	1/6 ± 0/14	3/6-4/0	BH-2

Sedimentation rate in this research is estimated 8.5 cm per year. Figure (4-8) shows different layers sediments age. By using this chart, sedimentation in different periods can be assessed. Average sedimentation in all 4m depth will be equals to 6.5cm per year if attributes cesium in 4m depth to 1954. Cesium in spot 3, in 350m depth shows growth, if it attributes to 1963, sedimentation to this depth will be 5.6cm per year. Thus sedimentation in different spots and layers are almost alike and if it has higher rate in some layers, it can be attributed to abrupt or unusual floods.

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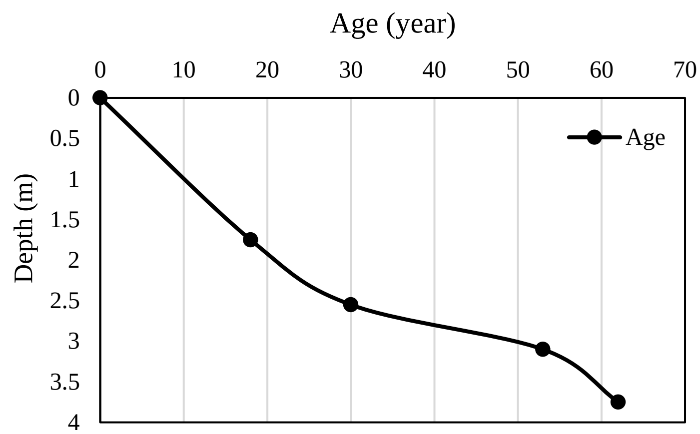

Figure4-8 sediments age in different layers

Table 4-6 cesium-137 vertical distribution and sediments calculated age in different BH

Sample code	Soil depth (m)	Cesium137 Bq/kg	year	Age
BH-1	1/6-1/9	4/1	1998	18
BH-1	2/4-2/7	9/3	1986	30
BH-1	2/9-3/3	3/8	1962	54
BH-1	3/5-4/0	1/0	1950	66
BH-2	1/7-2/0	4/5		
BH-2	2/4-3/0	4/2		
BH-2	3/6-4/0	1/6		
BH-3	1/5-1/8	2/5		
BH-3	3/0-3/2	<4		
BH-3	3/3-3/5	4/1		

4 Discussion And Conclusion

In order to determine sediments age and sedimentation rate in Anzali lagoon in north of Iran, a research was done in2017 with coring from sediments in south of the lagoon. Sediments grading, liquid and plastic limit, sediments texture and color in soil mechanic laboratory was measured. Moreover, the degree of cesium-137 in explants, in Atomic Energy Organization of Iran laboratory is determined. Results identified that sediments are mostly silt with low plasticity in green, light brown and blue. Most degree of cesium-137 is observed in 2.4 - 2.4 layer which sedimentation degree of 8.5cm per year is obtained if attribute it to Chernobyl disaster in 1986. This rate of sedimentation is rather high that shows that a great danger threats Anzali lagoon. One of these threats, is descending water depth in lagoon and as a result damage creatures` settlement. Thus protecting plans to save Anzali lagoon as the most important area of the country is necessary. Public communion and awareness plan about coast value, coastal slope managing plan, bioenvironmental managing program, land usage and coasts suitable covering plan, protecting environmental scenery, assessing and controlling program, providing coastal geography databases, providing unifying managing terms and conditions on coasts should be taken into account. Lagoon dredging and hydrophyte accumulation can be considered as the most important elements in Anzali lagoon revival.

Cesium-137 method consists of limitation as follow: (Asadi et al, 2012)

1) Considering half-life of cesium-137 and its loss from erosional spots, radioactivity of cesium-137 will be as sensitive as measuring and perceivable devices. Thus, there would be main limitations in dry and semi-dry lands because of low cesium-137 subsidence in soil loss identification.
2) Another limitation of this method is in spots that water and wind erosion happens simultaneously. Wind erosion cause different degree of sediment subsidence in understudy and reference spots. It makes an error in determining reference spot whole stock and incorrect analogy between reference spots with understudy spots.

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