Dating by using $^{137}\text{Cs}$ for marine sediment accumulation rate of Faw city / NW Arabian Gulf

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Abstract

The isotropic method based on measurements of $^{137}\text{Cs}$ activities has been applied for the determining sediment deposition rate in the cores from mudflat areas at the surrounding reaches of Faw city, Southern Basrah Governorate between Shatt Al-Arab River and Khwr Abdullah Channel. After collection of core sediments, each was cut into layers of 1 cm thickness. Each layer was cleaned, dried, milled, sieved through 0.2 mm sieve, put inside Marinalli beaker, sealed and finally put in gamma spectroscope for the measurements of $^{137}\text{Cs}$ activity. The gamma spectrocope used was fitted with NaI (Ti) detector 3x3 inch and a 1024 channel computer analyzer USX. The sedimentation rate in the area of study was estimated between (1.3 -1.5) mm / year for depth of 40 mm in core No. 1, which related to a period of 30 years, and for depth of 80 mm in core No.2 which related to a period of 52 years. Results obtained were explained on the basis of two major activities took place during the past years, the 1986 Chernobyl blast and the 1963 atmospheric nuclear weapon testing respectively.

Key wards: Gamma Spectroscopy, NaI(Ti), $^{137}\text{Cs}$, core sediment, dating.
Introduction

The activity concentration of $^{137}$Cs isotope is increased around the world as a result of many accidents (Regional training course, 2014). In marine environment, after accumulation of sediments in many regions due to tide, current speed and waves etc., it will cover the bank reaches of the beaches. The measurement of $^{137}$Cs activity concentration profiles in sediment cores is a very popular method for rapid and easy estimation of mean sedimentation rates in recent deposition layers. The procedure is based on the fact that the atmospheric pattern of $^{137}$Cs is well known, with a global maximum around 1963, when higher atmospheric nuclear weapons testing activities took place. The interpretation of sediment ages gives an age range for each depth interval, which is then presented as a probability distribution. There are many laboratory monitoring the activity of isotopes around the world such as group at the Riso National Laboratory, Denmark, at which the $^{137}$Cs contents in seawater have been monitored for the period 1972 to 1984 (Aarkrog et al., 1972), and $^{137}$Cs concentration in the air-surface was measured in Sweden, (Vintersved, 1987), from the 1950s up to the present days. Both sets of data will allow us to reconstruct the $^{137}$Cs concentration in seawater for the period 1954 to 1984, which are represented by the $^{137}$Cs time-marks can then be used to constrain the probability distributions of sediment ages, (Abril, 2004). Chernobyl incident affects many European sediments in which another activity peak for $^{137}$Cs appears in the layers (IAEA, 2012). This allows a very simple determination of the mean sedimentation rate. Nevertheless, this is not so easy when one is interested in describing the whole shape of the activity profile, or when the peak is not so distinct (IAEA, 2012). In such cases, the use of mathematical models appears to be a very powerful tool in understanding the sedimentation process and, consequently, for dating the sediment core. Atmospheric Flux of $^{137}$Cs given in La Spezia (NW Italy) between 1957 – 2009 shown in Fig (1), (IAEA, 2012). Radioactive decay ($^{137}$Cs half-life $T_{1/2} = 30.2$ years) (Abril and Garcia-Letn, 1994).

Fig(1). Atmospheric Flux of $^{137}$Cs given in La Spezia (NW Italy), 1957 – 2009 adopted from IAEA, (2012).

Area of study

Faw city lies at a distance about 100 km south of the center of Basrah Province in Iraq with position (N:29° 55' 54".6 / E:48° 29' 06".8) as shown in Figure (2). There are many sedimentation...
and erosion regions in sides of Shatt Al-Arab river. One of these sedimentation regions was in south of Faw city near the navigation channel. It is a tidal flat, so the deep water in the accumulation sediment region was during tidal between (0.5m – 1.5 m) and salinity value ranged between 32 and 35 part per thousand (ppt). The tidal system represents by northern part of the Gulf, which is known as semidiurnal. Area represented the high sedimentation rate to another regions as a result of Karun river and Tigris and Euphrates it was appeared a layers of sediments which approximately one centimeter thickness. In both sides direction of region in Khor Abdullah and navigational channel of Shatt Al- Arab, it have high speed surface current, the maximum value of the surface current,(0.91 - 1.5 m/s) (Al-Taei, 2010). The most of outstanding wind in the study area is north west.

\[ \text{Figure(2) . Location map for Southern Iraq, NW Arabian Gulf showing the study area of mud flats of Faw city.} \]

\section*{MATERIALS AND METHODS}

\[ \text{Fig(3). Core sampler for collection of core sediments.} \]
Results and discussion

The estimated atmospheric flux of $^{137}\text{Cs}$ from fallout around the world through the years ago in many regions is shown in figure 1 (IAEA, 2012). This activity construction which are different from one place to another one as an effected results of radioactivity sources, clearly there are two peaks were appeared in the graph within the measurements of the activity concentration of $^{137}\text{Cs}$ for core samples. For one of these peaks the $^{137}\text{Cs}$ atmospheric pattern is well known with a global maximum around 1963, when higher atmospheric nuclear weapons testing activities took place and the second peak is belong to Chernobyl accident at 26 April 1986 (Al-Battat et al., 2018).

In this study each core is cut into many pieces, each piece with 1 cm thickness. For core 1, activity concentration distributed of each sample was explained in fig (4). From this curve, the specific activities of $^{137}\text{Cs}$ radionuclide with different depths are listed in table 1. Table 1 shows the peak specific activity of 0.58 Bq/kg which represents the Chernobyl accident at 26 April 1986, the sediment has 40 mm depth, with this interval that gives (1.3)mm sedimentation rate per year which is comparable to results reported for another regions around the world. At Lake Michigan, the average sedimentation rate was 1.1 mm / year (Robbins, 1975) and a sedimentation rate of 0.70 mm / year was inferred from $^{14}\text{C}$ ages of individual shell fragments in San Francisco Bay, California (Fuller et al., 1999).

The relation between the age and sediments depth is shown in fig.5. On the other hand, the specific activity distribution in core 2 sediments is indicated in fig. 6, the second peak showed higher value compared with core No. 1, it reflects the effect of global maximum around 1963, when higher atmospheric nuclear weapons testing activities took place. The specific activity 1.16 Bq/kg which is compatible for depth 80 mm deposition for 52 years age. Figure 7 represents the distribution of samples depth compatible with the ages. Therefore, from these facts in this mudflat region the sedimentation rate recorded 1.5 mm/year, which is quite closed to the findings for core No. 1, since they are separated by just 1 km distant.

![Fig.4. Specific activity distribution of $^{137}\text{Cs}$ Bq/kg with depth for core 1.](image-url)
Table 1. Specific activity of $^{137}$Cs with depth layers for core 1.

<table>
<thead>
<tr>
<th>Specific activity Bq/kg</th>
<th>Depth (mm)</th>
<th>age (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.145</td>
<td>20</td>
<td>7.5</td>
</tr>
<tr>
<td>0.29</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>0.44</td>
<td>29</td>
<td>22.5</td>
</tr>
<tr>
<td>0.58</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>0.02</td>
<td>50</td>
<td>...........</td>
</tr>
<tr>
<td>0.01</td>
<td>60</td>
<td>...........</td>
</tr>
</tbody>
</table>

Fig. 5. Relation between age and depth in core 1.

Fig. 6. Specific activity distribution of $^{137}$Cs Bq/kg with depth for core 2.
Table. 2. Specific activity distribution of 137Cs Bq/kg as a function of depth (mm) with the age(year) for core 2.

<table>
<thead>
<tr>
<th>Specific activity Bq/kg</th>
<th>Depth (mm)</th>
<th>age (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.04</td>
<td>10</td>
<td>3.75</td>
</tr>
<tr>
<td>0.27</td>
<td>20</td>
<td>7.5</td>
</tr>
<tr>
<td>1.11</td>
<td>40</td>
<td>30.0</td>
</tr>
<tr>
<td>0.80</td>
<td>50</td>
<td>34.5</td>
</tr>
<tr>
<td>0.29</td>
<td>72</td>
<td>39.0</td>
</tr>
<tr>
<td>0.58</td>
<td>75</td>
<td>43.5</td>
</tr>
<tr>
<td>0.67</td>
<td>77</td>
<td>48.0</td>
</tr>
<tr>
<td>1.16</td>
<td>80</td>
<td>52</td>
</tr>
</tbody>
</table>

**Figure.7. relation between the age with depth for core 2.**

**Conclusion**

The sedimentation rate in this mudflat study region was higher than regions around the world such as Lake Michigan, as an average sedimentation rate of 1.1 mm / year (Robbins, 1975) and a sedimentation rate of 0.70 mm / year in San Francisco Bay, California (Fuller et al., 1999). Figures 5 and 7 revealed that the average sedimentation rate was this area might be intercepted by different natural layers of sediment which split the core layers clearly.
References


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