*Stud. Mar.*, 23(1): 57-64 UDC 543.52.054

# THE ENVIRONMENTAL STATE OF AQUATIC SYSTEMS THROUGH SEDIMENTS ANALYSIS: RADIOCHEMICAL APPROACH

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## ABSTRACT

Under natural conditions a lagoon environment is basically unstable and very complex and it can evolve quickly. In the Venice lagoon quite a number of human interventions have possibly made the morphology even more complicated than reasonably expected. Under these conditions the environmental survey of an area, even if detailed, is seldom representative.

A preliminary radiochemical survey of airborne radionuclides represents a unique tool to investigate the homogeneity of the whole sedimentary system. On the basis of this approach a detailed study of the homogeneous areas individuated, in accordance with the aims of the investigation can be successfully performed. The case study of the Venice Lagoon is examined.

*Key words*: aquatic systems, sediments, radionuclides and pollutants

# ISPITIVANJE STANJA VODENIH SISTEMA ANALIZOM SEDIMENATA: RADIOHEMIJSKI PRISTUP

## REZIME

Karakterisanje profila sedimenata praćenjem sadržaja nekih radioizotopa u njima, čija je inicijalna koncentracija bilo u vazduhu ili vodi konstantna ili dobro poznata, omogućava rekonstrukciju porekla radioizotopa u njma, a time I rekonstrukciju istorije sedimenata. Na primeru ispitivanja sedimenata lagune Venecije na polutante radioizotopima moguće je na analogan način primeniti istraživanja na Bokokotorski Zaliv.

*Ključne riječi*: vodeni sistemi, sedimenti, radionukleidi, polutanti.

## INTRODUCTION

Sustainable development and responsible care are imperatives in countries where, for different political or social and economical reasons, it is still possible to conjugate properly development and environmental protection. In this context equilibrium between economic development and public opinion should be reached. Moreover the introduction of innovative and environmentally compatible technologies can stop actual degradation especially in developing countries.

This kind of approach implies:

1. Introducing advanced technologies to minimise and control emissions in the environmental compartments (air, water, soil, biota).
2. Recovering of the already compromised natural environments.

Environmental conservation and pollution control have been among the key factors in research activities throughout the world in the past decade. The aquatic systems represent the ultimate sink of all wastes dispersed in fresh waters and in the soil and subsequently are the most potentially affected bodies of the ecosystem.

During the last century industrial growth and soil practices led to an increasing input of chemical and biological pollutants to coastal and lagoon areas. There is much general information available in literature on the negative effects of sediment pollution induced by industrial development and land urbanisation.

Sediments play an important role in defining the main chemical, physical and biological features of an aquatic environment. Sediments can act both as a source and a sink for nutrients, trace metals organic matter, etc., and they directly influence a wide range of chemical reactions that strongly affect the composition of the overlying water column. Once sediments have settled down a series of basic properties can be used to describe them and to give some indications about the possibility of re-suspension and transport. Moreover under suitable, undisturbed conditions sediments can document the history of past events and allow the reconstruction of antecedent environmental situations. For this purpose appropriate chronological methodologies are used; the most suitable techniques are based on concentration measurements of some radioisotopes whose initial concentrations in air or in water is almost constant or well known *[E.D.Goldeberg, IAEA 121(1973)]*. The radioisotopes associate with particulate, settle down regularly with it and are in this way included into sediments; hereafter their concentrations start to decrease because of radioactive decay: this allows the reconstruction of the sediment history. Two different kind of radioisotopes can be found in nature: the first one has got a terrestrial origin and includes mainly the isotopes of the three natural radioactive series, the

second one originates from the effects of cosmic radiation on earth and in particular on atmospheric components. Recently a new group of radioactive elements, due to anthropic activities, has come into view; it includes $^{137}Cs$, which is often used together with $^{210}Pb$ for sediment dating. It should be noted that even in those cases in which a detailed temporal reconstruction is difficult or impossible, the determination of radioisotopes in the sediment could give precious indications for understanding and making use of other available information. This kind of survey should be carried out through consecutive approximations, to avoid an excessive analytical charge. The extension and the morphological complexity of most aquatic systems make the study of a limited area quite profitless, since the indications obtained cannot be extrapolated to the whole system. The best solution is to carry out a preliminary survey to investigate the homogeneity of the system; on this basis it is then possible to plan a detailed study in accordance with the intents that are effectively achievable. The general features of the system evolution as concerns erosion/accumulation of sediments could be derived through a comparison of the relative radioisotopes contents at each sampling station. Using the maps of air-borne radionuclide distribution obtained in the preliminary survey, a detailed chronological reconstruction will be carried out for the sedimentary deposits of each homogeneous area. The aim of this phase is to obtain a characterisation of sediment profiles as wide as possible, not only from a radiochemical point of view: starting from the usual chemical and physical measurements for the characterisation of sediments, all other parameters linked to organic and inorganic pollution should be measured. This set of data will allow the detailed reconstruction of the inventories and of the fluxes of the pollutants present in the system and deriving from the drainage basin of the studied area.

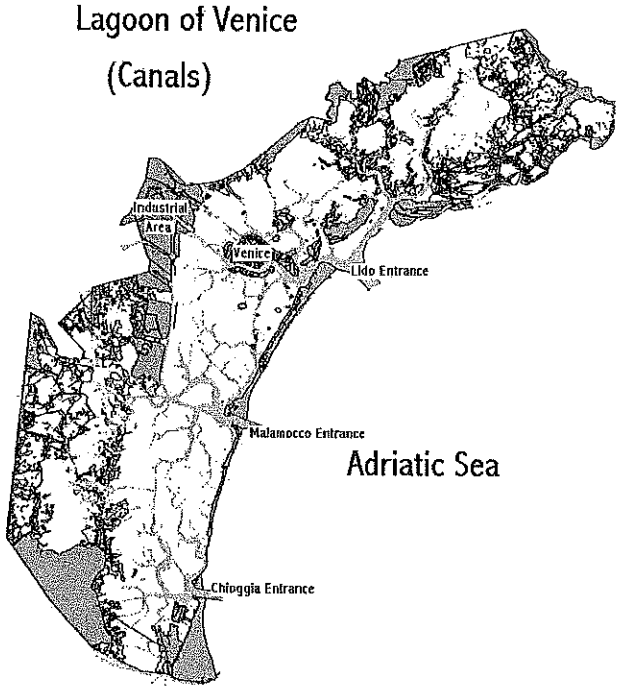
## CASE STUDY: THE VENICE LAGOON

*Site description.*

The Venice Lagoon is located between Adige and Piave rivers on the western coast of Northern Adriatic. The average depth of the shallow water body is 0.6m and the area is about 550 km2 wide. The tidal water exchange through the three port entrances (Lido, Malamocco and Chioggia) is about 3500 $m^3 s^{-1}$. The canal conformation, the shallowness of the area and the presence of "barene" (tidal banks) strongly reduce the propagation and amplitude of the tide in the inner parts.

The present configuration of the lagoon (Fig.1) is the result of a complex interaction of natural phenomena (starting from the Neolithic) up to an extended sequence of recent human intervention. Main anthropic interventions

regard the digression of Brenta River (1300 AD), the creation of embankment at the three port entrances to overcome silting and the dredging of some new industrial canals for large boats.




All these interventions have enhanced the influence of meteomarine phenomena on the lagoon system, which nowadays seems to increase in depth and more generally to shift from a transitional environment condition towards a reach condition.

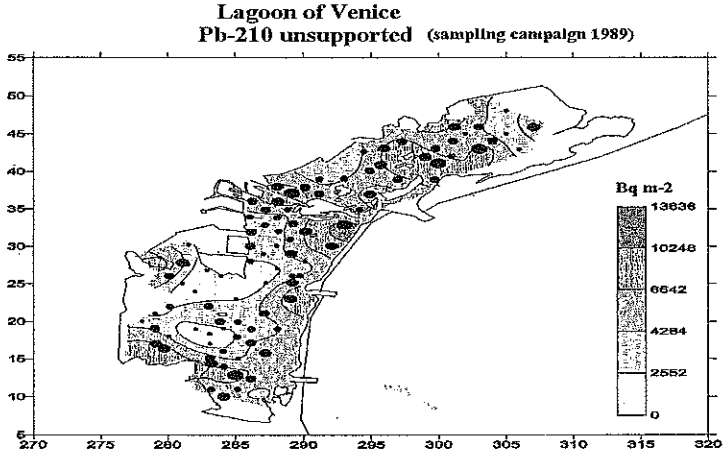
*Distribution and Inventory of Atmospherically delivered radionuclides.*

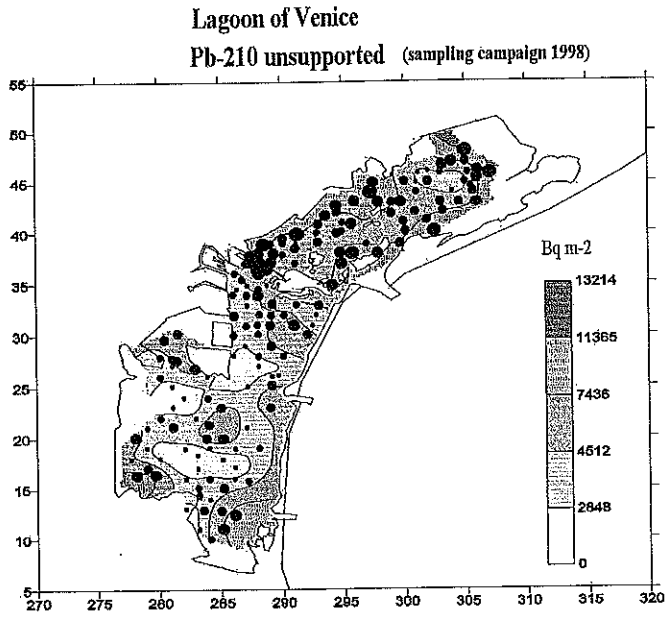
Sampling sites were chosen on the basis of a regular 1 km-meshed grid; in any case a distance not less than 50-100 m was kept from the many canals (Fig.1). Three cores, 1 m in length, were collected for each sampling station; the cores were regularly spaced, at 120° from a GPS geo-referenced sampling point. The three cores from each sampling site were extruded and subdivided in layers corresponding to the depths of 0-15 cm, 15-30 cm, 30-45cm and 45-60cm. Sediments from the same layer depths were mixed together in order to obtain only four representative samples.

Water content, grain size distribution and apparent densities were determined for each sample. The determination of the activities of a series of radionuclides ($^{210}$Pb, $^{234}$Th, $^{214}$Pb, $^{214}$Bi, $^{226}$Ra, $^{212}$Pb, $^{228}$Ac, $^{7}$Be, $^{137}$Cs e $^{134}$Cs) was mainly carried out by High Resolution Gamma Spectrometry (suitable intrinsic Ge planar detectors were used to determine low-energy emitters). After radiochemical data processing a selected number of samples, were analytically processed to determine heavy metals content (their bioavailability) and persistent organic pollutants.

The radionuclides activities determination along the sediment profile allowed measuring the *inventory* of air-borne radionuclides (basically included in the first 30 cm). Moreover, evaluating radionuclides distribution with depth, it was possible to put into evidence mixing phenomena and other physical disturbances. These mixing phenomena are quite recurrent in such a high anthropic influence area. Thus through inventories data analyses, it is possible to outline depositional homogeneous areas, while profile distributions allow the identification of the less modified areas; these areas are the most suitable ones to plan the study of agricultural, urban and industrial pollution phenomena evolution and sources.

As an example, in the next figures atmospheric $^{210}$Pb unsupported distribution maps are presented. Point size of sampling stations is related to sediment activities. These maps refer to 1989 and 1998 sampling campaigns, and through their comparison the actual evolution trend can be put into evidence.






CASE COULD BE STUDIED: THE KOTOR BAY

The pollutant examination of specific and unique Venice Lagoon by radiochemical approach of sediments could be the research way of one another specific and unique aquatic system, Boka Kotor Bay.

The Bay ecosystem has been impacted and degraded during the past a few decades by a combination of natural processes and more by the activities of mankind. Over the past several decades, the impacts of human activities have accelerated. Although the Bay as a whole is still fairly "clean" in comparison to other Adriatic coastal areas, but there are a number of contamination problems entering the Bay from point and non-point sources. Discharge of industrial, run-off and municipal pollutants have affected the Bay over the past years. B.K. Bay water, particularly near urban centres, probably contains polluted sediment, radioactive waste, heavy metals, and organic chemicals. The presence of such materials in the Bay water could have created problems associated with health and safety, biological resources and recreational activities.

We could say that the ecosystem of the Bay is relatively healthy in the comparation with those along the Northern and Middle Adriatic (Regner, 1996). This situation largely fortutions, due to a favourable combination of historical, geographic and geologic factors, rather than to any special efforts on our part.

The human population density is low in the region and the few urban centres are small by world standards. A smaller population dumps less waste into coastal waters. Also, there are a very few small sea marine or industrial complexes spewing toxic chemicals into the Bay. Newerthless, there are some areas in the Bay where geographic and geological conditions are such that contaminants can accumulate to levels that my cause problems. Many could come from far away and are transported here on currents of air or water. At the same time, all around the Bay communities dump untreated or minimally treated sewage directly into the sea or into the rivers that flow into it. The situation is depressingly similar for most communities around the Bay. This effluent is now treated to remove solids, but this has done little to reduce the input of organic matter, toxic chemicals and noxious bacteria.

A fundamental goal of the sediments analysis of the Bay by simultaneous radio chronological investigation on the collected cores could be carried out through excess $^{210}$ Pb and $^{137}$Cs activities in sediment layers is to understand the environmental changes being caused by natural phenomena and human activities, past and present environmental state of the Bay. This study would focus our atenttation on the accumulation of contaminated sediments and on their mobilization and transport caused not much by waves and current, but by bottom flow of fresh water.

Contaminated sediments generally contain many of anthropogenic and naturally occurring components. Studying of sediments can provide an understanding of how pollutants and particles are transported, deposited, recycled and stored in sea water. This research could be supported by following hydrodynamic and meteorological processes that have an important impact on Kotor Bay sedimentation. The Bay is quiet place, almost without a wind, waves and bottom currents (Mandić, 1998). But in the late summer, vrulje and rains arrives and mixes the entire water column. Especially that type of vrulje mixed the water from bottom to top resulting in sediment resuspension and transport. The information of about the location, season time and number of bottom fresh water coming is very important for sedimentation and their pollutions. The location of the salt water/fresh water interface is needed in to provide detailed information about locations and extension of sedimented areas or understanding of the processes of the sedimentation and pollutants movement. The studies would be undertaken to indentiffy the source, distribution and fate of sediments and pollutants.

The goal of the B. K. Bay program is to improve our scientific understanding of factors, which influence the quality, and preservation of the Bay environment. The program would evaluate present environment condition of the Bay and describe the processes and rates of change. The project would investigate both: the sedimentation history and the temporal sedimentary

processes. The sediment research investigation would provide information to help understand natural and human stresses on the ecosystem of the Bay. A sediment studies, their mapping and sampling can provide an understanding of pollutants nature, deposit, recycle and influence on the sea biota.

## CONCLUSION

The actual degree of wastes in the B. K. Bay can be completely established only after a monitoring program to be carried out in the near future. The Kotor Bay program would be primary concerned to identify and define contaminated sediments, mixing and accumulation of sediment processes in relation to the behaviour and distribution of radioactive and non-radioactive contaminants.

Long-term monitoring and observations would provide a description of the mean condition, as well as the seasonal, annual and climatic variability. Such descriptions are essential to successfully distinguish long-term trends caused by anthropogenic effects from the effects of natural changes.

Acknowledgement. I wish to thank M. Faggin and V. Corrado for their invaluable assistance in collecting the sediment samples. This work was funded by Ministry of Public Works - Water Authority of Venice, trough Consorzio Venezia Nuova (Law 798/84).

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