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Study on the behaviour of radionuclides in seawater in the Persian Gulf and Caspian Sea area, (part of a coordinated programme on marine radioactivity studies)

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FINAL REPORT

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Introduction

The increasing tendency of pollution incidents in the aquatic environment requires a better understanding of the behaviour of various potential pollutants, such as radionuclides and trace metals, in this environment in order to evaluate the effect of man's input of these potential pollutants into the aquatic environment.

In June 1973 a Research Project was initiated at the Teheran University Nuclear Centre to study the distribution of certain radionuclides and trace elements in Iranian coastal waters along the Persian Gulf and the Caspian Sea. The investigation covered measurements of uranium, radium-226 and strontium-90 by radiochemical methods and trace metals by flameless atomic absorption spectrophotometry on the water samples collected from the stated areas.

The results presented were obtained from work carried out for two years, but due to special circumstances, the continuation of the investigation had to be postponed. However, since the results obtained call for further investigation, we are planning to continue the research at the Teheran University Institute of Nuclear Science and Technology.

The assistants in this project included Dr. F. Moattar, Mrs. S. Samii and Mr. R. Jalaly Behzad.

I would like to thank the Iranian Imperial Navy for providing facilities for sampling in the Persian Gulf and the Ministry of Agriculture for sampling facilities in the Caspian Sea, the Atomic Energy Commission of Iran and the Centre for Nuclear Research for laboratory facilities, as well as the IAEA for partial financial support. I would like also to acknowledge the valuable advice of Dr. R. Fukai of the International Laboratory of Marine Radioactivity, IAEA at Monaco and thank him for providing the possibility of presenting this report during my stay at the Laboratory from March to May 1976.

Sampling sites

1. Persian Gulf: a sinking shallow water basin, an extension of the Indian ocean covering an area of 239,000km^2, bordered by the southern part of Iran and the northern Arabic peninsula. Its length is 985 km

and its maximum width 330 km. The narrowest part of the Straits of Hormuz is 56 km; the depth varies from 25 to 100 meters; the water volume is 6000 km^3. The main inflow comes from the head of the Tigris Gulf, Euphrates and Karern rivers. Salinity varies from 37-42 ‰. The increase of salinity with depth suggests a surface inflow from the Indian ocean and a subsurface outflow of sinking high salinity water. Chlorinity is 21-23 ‰ and higher compared with 19 ‰ in open ocean. Samples in this gulf were taken from the Iranian coastal water near Bandar abbay, Bandar Bousher and in the area where the Shah-Al-arab enters the gulf.

2. Caspian Sea: the world's largest closed water mass is bordered by the northern part of Iran and the southern part of the USSR. The maximum length is 1200 km in the north/south direction and the width in the widest area is 560 km; the depth varies and its maximum (about 1 km) is found in the southern part. The main inflow comes from the Volga rivers in the northern part. The discharge in the southern part proceeds from rivers originating in the Alborz range, the shore is mostly alluvial. The salinity varies from 11, 97-13, 54 ‰ and the chlorine content is 4.7 - 5.2 g/l, approximately 4 times lower than the average open ocean content. The temperature of the surface water along the Iranian coast varies from 7-9°C in winter to 20-22°C in summer. Samples were taken along the Iranian coast from west to east in the astara, Pahlavi, Babolsar and Bandar Shah area.

Sampling procedure

Surface water samples were collected in 20 litre plastic containers, pre-washed with hydrochloric acid and sea water.

Caspian Sea samples were taken in two different seasons and four localities along the Iranian coast at about 1-1.6 km from the shore,

Persian Gulf samples were taken lalso from the Iranian coast line at 12-25 km from the shore.

Some samples were also taken from the Karun river and Brakish water in Shah-Al-arab.

The Iranian Navy authority in the Persian Gulf and the Fisheries Department of the Ministry of Agriculture in the Caspian Sea provided the cruising facilities for sampling.

Analytical methods

The major constituents such as Na, K and Ca were measured by flame photometry, Cl by $AgNO_3$ titration and SO_4 by gravimetry on $BaSO_4$ precipitate.

Uranium was measured by fluorimetric and spectrophotometric method.

Radium-226 was measured by $BaSO_4$ precipitation and ^{222}Rn emanation method.

A flameless atomic absorption method was used for measuring trace metals. Some samples were examined for Zn, Cd, Pb, Cu and Hg by anodic stripping voltammetry at the International Laboratory of Marine Radioactivity at Monaco.

RESULTS

1. Major components

The results of measurements for Na, K, Ca, SO_4, Cl and total salt are summarized in the following table.

	Persian Gulf	Caspian Sea	Open Ocean Average
Na	9500 - 13750 ppm	3500 - 4625 ppm	10770 ppm
K	360 - 440 "	70 - 110 "	380 "
Ca	500 - 630 "	330 - 390 "	412 "
Cl	21395 - 22917 ppm	4765 - 5265 "	18800 "
SO_4	2960 - 3720 "	2540 - 3050 "	3600 "
Total salt	38.14 - 42.05 ‰	11.97 - 13.43 ‰	35 ‰
pH	8 - 8.2	8 - 8.3	≈ 8

2. Radionuclides

Uranium

Concentration of uranium in the Persian Gulf varies from 3.4×10^{-3} - 4.1×10^{-3} ppm and 3.0×10^{-3} - 7.4×10^{-3} ppm for the Caspian Sea. The average reported for open ocean is 3.3×10^{-3} ppm. Therefore, it seems that some samples from the Caspian Sea have a higher uranium content compared with the oceanic average.

Radium

Radium-226 content of samples from the Persian Gulf varies from 0.04 - 0.06 Pg/1 and 0.022 - 0.035 Pg/1 for the Caspian Sea. The oceanic average is 0.3 - 0.16 Pg/1.

Strontium-90

With the use of only 20 litres of sample, we were not able to measure the ^{90}Sr with this procedure.

3. Trace metals

The results of measurements of some trace metals are as follows:

Cu - the content varied from 7 - 8µg/1 for the Persian Gulf and 2 -3µg/1 for the Caspian Sea. The range for ocean surface water is 0.3 - 3.8µg/1.

Mn - the content ranges from 5 - 6µg/1 for the Persian Gulf and 1.2 - 2.8µg/1 for the Caspian Sea. Reported open ocean surface water figures are 0.7 - 3.2µg/1.

Zn - varies from 7.3 - 9.7µg/1 for the Persian Gulf and 1 - 1.4µg/1 for the Caspian Sea. The reported oceanic nearshore average is 0.6 - 12.6µg/1.

Pb - the anodic stripping voltammetric measurement gave a value of 0.1 - 2.1µg/1 for the Persian Gulf and 0.4 - 4µg/1 for the Caspian Sea, while the reported oceanic average is 0.2 - 4.8µg/1 for nearshore areas. Atomic absorption gave a high value of 8 - 10µg/1 for both regions.

Fe - the content for the Persian Gulf is 3.9 - 9.7µg/1 and 6 - 7µg/1 for the Caspian Sea.

Cd - was measured by anodic stripping voltammetry and a concentration of 4 - 4.3µg/1 was obtained for the Persian Gulf whereas highly concentrated (95-121µg/1) figures result from the Karun River area but, before speculating upon this, a re-investigation is necessary in this region. The Caspian Sea gives a concentration of 4.3 - 5.5µg/1.

Hg - the mercury content of one sample from the Persian Gulf by anodic stripping voltammetry gave a concentration of 21.4 ng/1 which lies in the range of oceanic concentration 16 - 93 ng/kg.

Conclusions

The results indicate an obvious difference between two water bodies compared with open sea water, but at this stage of information a detailed explanation on the geochemistry of these water masses will not be considered.

Regarding the environmental pollution, both these areas can be considered as being rather closed bodies and very much susceptible to polluting material. The Persian Gulf can be considered as a drainage for bordering countries such as Iran, Iraq, Saudi Arabia and even Turkey and Syria; the main source of pollution arising from oil industries and exploration activities along the Iranian coast of the Caspian Sea. There is not, at the moment, a major industrial set up that would be regarded as hazardous but some consideration should be given to industrial development. Furthermore, the oil industries, power reactors and other industrial installations in Soviet sites might cause some pollution in this confined body of water.