Caspian J. Env. Sci. 2006, Vol. 4 No.1 pp. 77~81

CJES
Caspian Journal of Environmental Sciences

[Short Communication]

The Pattern of Caspian Sea Water Penetration Into Anzali Wetland: Introduction of a Salt Wedge

M. Sharifi
Razi University Centre for Environmental studies, Dept of Biology, Faculty of Science, Baghabrisham 67149, Kermanshah, Iran E-mail: sharifimozafar@gmail.com

Abstract
Measuring salinity of water at different depths along six transacts at the mouth of the wetland and along five tributaries connecting the wetland to the sea the extent of Caspian Sea penetration into Anzali Wetland was determined. The results demonstrated a depth-dependent salinity gradient extending up to 10 kilometres into the wetland. A pattern of saltwater and freshwater interface is presented and the role of this interface in enhancing sedimentation is discussed.

Key words: Anzali Wetland, Caspian Sea, Frontal Systems, Point Source Pollution, Salt Water Interface

Introduction
The existence of salinity gradients at the interface between fresh water and salt water particularly in estuarine waters has been known for long time (Duck and McManus, 2003). Further observations on salinity variations within estuaries have provided the physico-chemical basis for the long-established classification of estuaries into 'salt wedge', 'partially-mixed' and 'well-mixed types' (Pritchard, 1967; Dyer, 1994). In the salt wedge estuary the relatively fresh water lies upon the more saline bottom waters along a readily detectable boundary, a type of frontal system or front, known as the halocline, which extends across the estuary. The recognition of a halocline in such aquatic environments has helped to better understand the nature of mixing between saline and fresh waters and also the effects of this mixing on the pattern of surficial foam and debris (Duck and Wewetzer, 2001). It was also known that in the presence of fronts between fresh water and saline water diffusion of pollutants from point sources released into marginal waters will not become transferred to the main body of the sea water and may not become dispersed widely (Reeves and Duck, 2001; Acha *et al*, 2003).

Although in the last two decades the presence of halocline dividing waters of contrasting salinities, suspended sediment concentrations and thermal characteristics has been increasingly explored (Simpson and Nunes, 1981; Simpson and Turrell, 1986), little attention is paid to the interface between rivers and saline waters in big saline lakes and semi-closed seas where tidal fluctuation is absent or insignificant. The main purpose of this study is to determine the extent of salt water penetration into the Anzali Wetland and the slope of the inclined interface in the five tributaries connecting Anzali Wetland to the Caspian Sea.

Materials and Methods
Study Area
The Anzali wetland is located at south-western corner of the Caspian Sea beside the delta of the River Sepidrood. The catchment area of the wetland is about 3740 square kilometres, of which more than 2000 square kilometres are flat terrain and the rest consists of rolling hills and mountains. The area is located between 48°46′ and 49°43′ longitude and 36°54′ to 37°34′ latitude. The lowlands of the basin are intensively cultivated for rice and the remaining natural cover of the upland is a temperate deciduous forest. The area benefits from considerable precipitation (1500 mm) and does not have a dry season. Therefore, the wetland, although it experiences some sea

water penetration, is a freshwater ecosystem. The waterlogged area of the wetland varies considerably with season, and is strongly influenced by the well-known fluctuation of the Caspian Sea as dictated by the hydraulic gradient between sea and wetland. Recent evaluations indicate that since 1929 the extent of the Anzali wetland has decreased from 300 to 100 square kilometres (Shantia, 1989). A recent rise of Caspian Sea level has expanded the wetland well beyond the pervious circumference, around which considerable land has been drained and cultivated during the last two decades.

Sampling

A modified Irwin water sampler was used to collect water at desired depth. The conductivity was measured at place on a small boat using a Harris conductivity meter. The samplings were conducted at three points along six transacts at the Shipping Channel and continued along the five water courses connecting Anzali Wetland to the Shipping Channel at approximately every 500 metres until the salinity at surface became equivalent to that of the salinity at bottom. The water courses connecting Anzali Wetland to the Caspian Sea include Shanbeh Bazar Roga, Nahang Roga, Rassteh Khaleh Roga, Pir Bazar Roga and Ssossar Roga. At any sampling site the water samples were obtained from surface, bottom and mid distance between the two.

Results

Changes in electrical conductivity of water at three different depths on the five tributaries (Shanbeh Bazar Roga, Nahang Roga, Rassteh Khaleh Roga, Pir Bazar Roga and Ssossar Roga) of Anzali Wetland are shown in Fig 1. On the basis of the salinity values obtained at the bottom of these water courses the extent of salt water penetration into Anzali wetland is demonstrated in. Values obtained for conductivity of water at surface in all sampling sites have shown small variations extending from 1000 micromhos in most remote sections of the wetland to 5000 micromhos at the end of the Shipping Channel which is in close vicinity to the sea water. In contrast to the surface water, variation in values obtained from various depths at different sampling sites is considerable. The extent of changes in salinity is well correlated with the depth of water courses indicating that salt water penetrate into the wetland (Figure 2). The pattern of saltwater penetration into Anzali Wetland indicates that although a salinity gradient persists in Anzali Wetland but the stratification between waters with different salinity fade out as one move from the sea into the wetland. With the diffusion of the sea water driven by hydraulic gradient, difference in density of salt water along the watercourses and by the decline of wave action, the differences between salinity decreases until it becomes equal at all depths.

Discussion

Salinity variations have been known to exist in estuaries since the pioneering observations of Fleming in early nineteen century who collected water samples from different depth and determined the salinity gradient (Dyer, 1994). Although the way by which Caspian Sea penetrate into Anzali Wetland may differ in many respects when is compared with estuaries. It appears that data obtained from this study indicate that the interface between Anzali Wetland and Caspian is similar to a typical salt wedge. Tidal fluctuation in the Caspian Sea is not noticeable and probably is biologically insignificant. Absence of the tidal fluctuation may characterise the interface between freshwater and sea water. Moreover, Caspian Sea water is much less saline than the open sea but it is still some 50 times more saline than some of the tributaries which feed Anzali Wetland. In the salt wedge estuary the relatively fresh water lies upon the more saline bottom waters along a readily detectable boundary, a type of frontal system or front, known as the halocline, which extends across the estuary.

Figure 2 demonstrates the relationships between depth and salinity in different water courses. This figure is based on information obtained on all sampling sites. However, information obtained from the Shipping Channel which is common in all watercourses is considered here only once in order to prevent overrepresentation of the data. The general relationship between depth and salinity does not follows a linear pattern because at each sampling site other factors such as distance from sea, direction toward the sea and topography at water course bed are to some extent influential to the amount

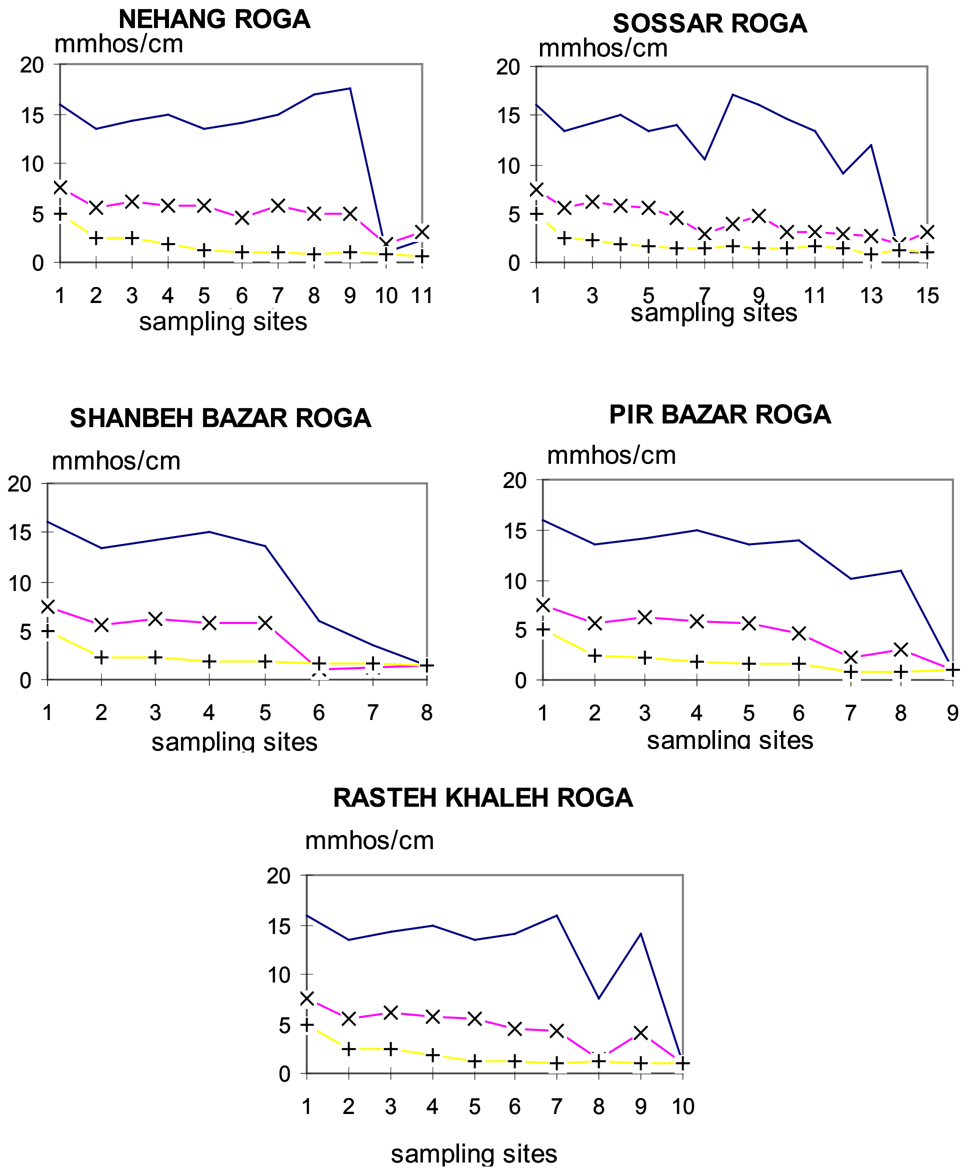

Fig 1. Electrical conductivity of water at surface (+), bottom (-) and mid-depth (×). Distance between each sampling sites is roughly 400 metres.

of salinity. For example Shanbeh Bazar water course which is the closest water course to the sea has a linear relationship between salinity and depth with high coefficient of variation. Similarly, Sossar water course which is farthest of all the water courses to the sea has a very weak correlation between depth and salinity.

The role of salt water interface on the rate of sedimentation in Anzali Wetland is not fully understood. It has been reported that the rate of sedimentation in Anzali Wetland has been unusually high (Shantia, 1989). This has been inferred on the basis of rapid filling of sediment traps constructed in the inner parts of the wetland. In other studies it has been shown that salt water interface with freshwater water may influence the rate of sedimentation by various mechanisms such as ion adsorbtion to the colloidal particles. In a dilute colloidal suspension in water the suspended solids remain in complete dispersion. In this situation, the particles tend to repel each other, permitting each particle to act independent of the others. Dispersion of particles is encouraged by high pH values and the size and nature of the colloidal particles. Moreover, the amount of multi charged ions

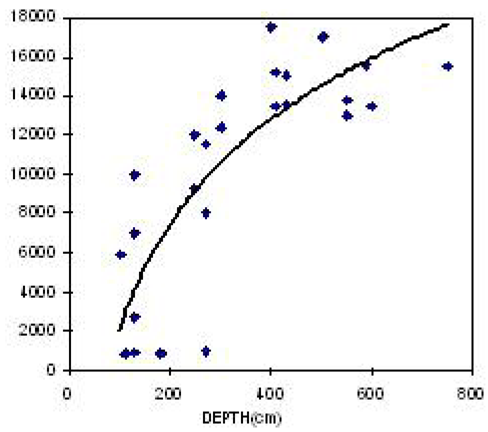

Fig 2. A regression analysis of depth versus salinity at various sampling site in Anzali Wetland.

which are more tightly adsorbed by a micelle together with contraction of the micelle and temperature are other factors that can control the rate of sedimentation. Although highly monovalent ions such as Na^+ which are not very tightly held by the micelle, are dominant in sea water, but constant collision of saltwater and freshwater has a significant role in flocculation of suspended solids coming from basin to the sea.

It has been shown that sedimentation at the mouth of estuaries is to a large extent due to flocculation of suspended materials under the influence of sea water electrolytes (Dyer, 1994). The presence of saltwater layer beneath the freshwater in Anzali Wetland may have promoted sedimentation in some parts of Anzali Wetland. The catchments area of Anzali Basin is relatively small (3470 km^2) and total suspended solids in various part of the wetland are not characteristically high (Shantia, 1989) yet there are reports of accelerated sedimentation in the wetland. Further investigation is necessary for clarification of the sedimentation under influence of different waters with differing salinity.

The halocline in Anzali Wetland is under influence of wave actions, long term fluctuation of the Caspian Sea and the annual cycles in freshwater discharge from the Anzali Basin. There is no available evidence supporting that the long term effect of this particular interface has caused any adaptive consequences in fresh water plants and animals. It is more probable that factor compensation in this biota has taken place along the halocline in the form of species composition change. Compensation along the salinity gradient may also involve development of genetic races or ecotypes. Further investigation for recognition of community characteristics and variation in individuals are recommended in and around the interface.

In estuaries the tidal fluctuations are important ecological factors, in providing energy, nutrient and reducing the community respiration. In wetlands that are interfaced with open sea, the easy access to nutrient and energy from sea water together with the regular fluctuation in the physical conditions, provide an environment in which an orderly process of community development is not possible. Thus the system remains more or less ecologically young and simple. Prolong condition governing the estuarial environment also has evolutionary significance and has caused peculiar adaptations for life in the tidal zone. Generally, plants and animals living in these environments have broad ranges of tolerance to extreme physical conditions.

In the absence of a turbulent interface and the tidal zone, the Caspian Sea interface with Anzali Wetland is characterised by a consistent halocline which remains calmly beneath the freshwater. The presence of a constant layer of saline water in parts of Anzali wetland may cause some nutrient being transported to the wetland but unlike open sea cannot help to reduce the community respiration by removing unwanted material to the sea.

The Caspian's low salinity is due to freshwater input (Kosarev and Yablonskaya, 1994). The Volga River contributes up to 82 per cent of the inflow with the rest supplied by some 130 other rivers, principally Ural, Kura and Atrak (Dumont, 1995). The high salinity of water in some water courses in Anzali Wetland especially on stormy days has been a familiar phenomenon. Early this century, Rabino the French council at Rasht reported salt water penetration in Mianposhteh (Shantia, 1989). The pattern and chemistry of the interface has been shown to dramatically influence water quality (Sharifi, 1990) and nutrient cycling (Sharifi, 1989) in some parts of Anzali Wetland. Recent rise of Caspian Sea and increased pollution load in many water courses in Anzali Wetland, demands further attention toward the understanding and monitoring of the extent of this penetration. It is also important to investigate the possible role of this phenomenon in developing increased sedimentation and enhancing anaerobic conditions created in polluted areas.

REFERENCES

Acha, E. M., Mianzan, H. W., Iribarne O, Gagliardini, D. A., Lasta, C. and Daleo, P. (2003) The role of the Rio de la Plata bottom salinity front in accumulating debris. *Marine Pollution Bulletin* **46**, 197-202.

Duck, R. W., and McManus, J. (2003) The effects of frontal systems on mixing in estuaries. *ECSA 8 Mixing/Modelling*. **6**, 151-155.

Duck, R. W. and Wewetzer, S. F. K. (2001). Impact of frontal systems on estuarine sediment and pollutant dynamics. *The Science of the Total Environment* **266,** *23-31.*

Dumont. H. (1995) Ecocide in the Caspian Sea. *Nature* . **377**, 176- 180.

Dyer, K. R. (1994) Estuarine sediment transport and deposition. In K. Pye (Ed.) Sediment Transport and Depositional Processes, Blackwell Scientific Publications, Oxford, 193- 218.

Kosarev, A. N. and Yablonskaya, E. A. (1994) The Caspian Sea. SPB Academic, The Netherlands. pp. 37- 62.

Mason, C. F. (1994) Biology of Freshwater Pollution. Longman Scientific & Technical. pp. 95- 123.

Pritchard, D.W. (1967) Estuaries: Sediment transport and sedimentation in estuaries. In G.H. Lauff (Ed.) Estuaries, *American Association for the Advancement of Science*, pp. 158- 179.

Reeves A. D. and Duck, R. W. (2001). Density fronts: Sieves in the estuarine sediment transfer system? *Physics and Chemistry of the Earth* **26**, 89- 92.

Shantia, H. (1989) Effects of Caspian sea level on Anzali wetland ecosystem (in Farsi).. Proc. Caspian Sea Level Expansion Seminar. Ramsar, July 1989. pp.141- 142.

Sharifi, M. (1989) Summer Release of Phosphate in Anzali Wetland. In the proceedings of the sixth Chemical and Chemical Engineering, Rasht. pp. 43- 44.

Sharifi, M. (1990) Assessment of Surface Water Quality by an Index System in Anzali Basin. In The Hydrological Basis for Water Resources Management. Ed Shamir, U., and Jiaqi, C. Institute of Hydrology, Wallingford, Oxfordshire, UK. IAHS Press. pp163- 171.

Simpson, J. H. and Nunes, R. A., (1981) The tidal intrusion front: An estuarine convergence zone. Estuarine, *Coastal and Shelf Science* **13**, 257- 266.

Simpson, J. H., and Turrell, W. R. (1986). Convergent fronts in the circulation of tidal estuaries. In D. A. Wolfe (Ed.) Estuarine Variability, Academic Press, New York, pp. 139-132.

(Received: Jan. 14, Accepted Mar. 23 , 2006)