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Review

Ecological integrity of wetland, their functions and sustainable use

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It is estimated that 90% of sewage in cities in developing countries are today discharged untreated into water bodies. The physical, biological, chemical and geologic interactions among different components of the environment that occur within a wetland. Anzali wetland complex is a good example of a natural wetland, characteristic of the South Caspian lowlands. It supports an extremely diverse wetland flora and fauna. Anzali wetland supports over 1% of the regional Middle East wintering populations of several species of waterbirds. Anzali wetland complex as a large and freshwater lagoon fed by several rivers, separated from the Caspian Sea by a dune system; supports extensive reed beds and abundant submerged and floating vegetation. It is vital life support system for many biological communities as it has so many different fishes like caviar that is the best in the world and supports a major commercial fishery. It has marvelous climate and beautiful views for tourists' attraction as an important recreation center in the north of I. R. Iran.

Key words: Wetlands, function, environmental problem, Caspian sea, Anzali wetland.

INTRODUCTION

The largest wetland in the Middle East and Western Asia is situated in southern Iraq and adjacent Iran. This paper is an overview of the wetland ecosystems in I. R. Iran, in-cluding the North of Iran and along the Caspian Sea (Fi-gure 1). A particular focus of the paper is to review what the author terms "heritage values" of wetlands which in-clude natural history, ecological information storage, ha-bitat for rare and endemic species, archeological uses and the current human uses of wetland systems for con-sumptive and non-consumptive uses. Particular attention will also be paid to human uses that degrade wetland ecological integrity and sustainability. Literature which ad-dresses human use values and functions of wetlands.

With the emergence since 1971 of the Ramsar Con-vention (The Convention on Wetlands) as a powerful tool for promoting the sustainable use and conservation of wetlands, the functions and values of wetlands are incre-asingly recognized in local, regional and international land-use planning and management processes. There are many different definitions of wetlands, probably as many as there are user or interest groups. The Ramsar Convention defines wetlands as "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters". This is a very broad definition that recognizes the often dynamic nature of wetlands and allows the consideration of the place that they have within the broader context of the landscape. This is crucial as wetland management needs to take into account the hydrological linkages, tem-poral cycles and changes and the terrestrial components of wetlands. There are more than 70, 000 constructed wetlands around the world at present (Vymazal and Kröp-felová, 2008; Kadlec and Wallace, 2008).

Wetland function

Constructed wetlands for water pollution control are be-coming an accepted technology worldwide. Recent inven-tories have indicated that there are more than 7,000 con-structed wetlands in Europe and North America, with the number increasing in central and South America, Austra-lia and New Zealand as well as Africa and Asia (Water 21, 2000). Constructed technology is popular because these systems serve money and works well. They require none or small energy, can be constructed from native soils with minimum concrete and steel. Operator skills and training requirements are minimal. Constructed wetlands are therefore appropriate technology for remote and developing areas where regular supply of energy may not be available and operating requirements are often ill matched to local skills (Mara et al., 1992). Successfull case studies indicate that constructed wetlands significantly reduce suspended solids (SS), biological oxygen demand (BOD), pathogens, heavy metals and excessive nutrients from wastewater (Gersberg et al., 1984; Rogers et al., 1991; Ojo and Mashauri, 1996; Mashauri et al., 2000).

Globally, forested wetlands occupy more than 330,000, 000 ha (Matthews and Fong, 1987). These wetlands are vital habitats that harbor high levels of floral and faunal biodiversity including critical bird and mammal habitat (Saenger et al., 1983), significantly contribute to fisheries productivity, and act as nursery sites for fish and crustaceans (Robertson and Duke, 1987). They also regulate run-off quantity and quality (Lugo et al., 1988), mitigate flooding (Saenger et al., 1983), control erosion and modify geomorphological processes (Carlton, 1974). Wetlands are also important as sources of timber (Putz and Chan, 1986) , firewood and food (Saenger et al., 1983); and when used wisely, provide numerous recreation, tourism and educational opportunities (Saenger et al., 1983).

The concept of wetland functions is relatively new in both the regulatory and scientific arenas. For many years wetlands were considered nuisances and wastelands (Washington State Department of Natural Resources, 1998). The functions found within a wetland were not considered important enough to study and understand. Today, however, we know that the functions performed by wetlands are important and interacts with other aspects of the landscape around it.

Wetlands are multi-functional; they provide services, such as water purification and regulation of water flows, fishery and other resources for human and non-human uses, habitats for plants, animals and micro-organisms and opportunities for recreation and tourism. Their intrinsic hydrological processes buffer against extremes as droughts and flooding. During rainy periods, wetlands absorb water and therefore reduce flood risks. In the dry seasons wetlands gradually release their water and thus ensure water is available even in the non-rainy periods.

This is important for people as well as to maintain basic ecological processes. In a broader perspective, the wetlands are important water reserves feeding into and replenishing ground water reserves and sub-soil aquifers. Largely because of water, wetlands are a source of life: much of the world's biodiversity depends on or is linked to it. This includes many endangered and or migrant species. Wetlands are thus parts of a global network of water-dependent cross-frontier resources and processes. As such, water and wetlands are integral parts of a bigger picture whose constituents can not be managed in isolation.

The multi-functionality of wetlands makes it implicit that sound management of wetlands can only be achieved through inter -sectoral land-use planning, integrating the development options and constraints offered by each as well as the combination of specific wetland functions and resources, within the overall context of the hydro- ecological wetland processes and the socio-economic situation. This means that the values placed on wetlands will be central in policy development and management decisions. Hence the increased recognition to involve from the outset of wetland development and management planning all stakeholders and particularly the people that depend on these areas for their livelihood.

During the last century many human impacts on wetlands have occurred drainage (Fojt, 1994), fragmentation (Marrs, 1993) and overgrazing (Bardgett et al., 1995). An important impact is enhanced nutrient input into wetlands, either directly through application of fertilizer in order to increase the biomass production, or indirectly, through runoff of higher concentrations of nutrients caused by more intensive agricultural use of uplands and through increased atmospheric deposition.

Wetlands are increasingly recognized as valuable natural systems providing useful services to society such as flood abatement, water purification, groundwater recharge, erosion control and biological diversity (Ewel, 1997). International recognition of the value of wetlands is apparent through collective action in the Convention on wetlands of International Importance (Mitsch and Gosselink, 2000).

A number of studies have addressed the restoration of wetlands on a large scale to minimize the impacts of agricultural and urban runoff on coastal bodies of water. Most wetland ecologists do not have a difficult time defining (in some manner) just what constitutes function in a wetland (Table 1). However, very few attempts are made to directly measure function.

Kentula et al. (1992) suggest using indicators or those variables seen as closely related to a particular function. However, with wetland mitigation monitoring, Kentula et al. (1992) noted that “Measures of wetland structure, e.g. site morphology or species present, are readily available and more often meet the requirements of expediency and economy than do measures of function.” In effect, biophysical structure is assumed to correlate highly with function, even though that might not always be true (and is rarely shown directly).

Measurement of function is complex and expensive and as a result, is not often the objective of wetland site assessments. If function equates to a process or a rate, then analyzing function requires at least two temporally distinct measurements of some structural aspect such that a minimal determination of flow or flux can be obtained. For example, net primary production is often estimated from standing crop measurements collected once late in the growing season (Craft et al., 1999). Truly calculating production requires many measurements throughout the growing season (Dilustro and Day, 1997).

Table 1. Examples of wetland functions as defined by several authors.

Hammer (1992)	Smith et al. (1995)	National Research Council (1995)	Cronk and Fennessey (2001)
Life support.	Short-term surface water storage.	Short-term surface water storage.	Hydrology.
Hydrologic modification.	Long-term surface water storage.	Long-term surface wate r storage.	Biogeochemistry.
Water quality changes.	Storage of sub-surface water.	Maintenance of high water table.	Plant and animal habitat.
Erosion protection.	Moderation of groundwater flow.	Transformation and cycling of elements.	
Open space and aesthetics.	Dissipation of energy.	Retention, removal of dissolved elements.	
Geochemical storage.	Cycling of nutrients.	Accumulation of peat.	
	Removal of elements and compounds.	Accumulation of inorganic sediments.	
	Retention of particulates.	Maintenance of characteristic plant communities.	
	Export of organic carbon.	Maintenance of characteristic energy flow.	
	Maintenance of characteristic plant and animal communities.		

Not: All wetland types exhibit all functions.

Another means of indirectly addressing function is to assign certain plants to functional groups (guilds, in a sense). Walker et al. (1999) discussed plant functional groups in terms of global change, and their list of plant functions varied from fixed and stored carbon, to nitrogen released annually, to water uptake. Furthermore, wetlands perform many types of functions, but not all wetlands perform the same functions, nor do similar wetlands provide the same functions to the same level of performance (Clairain, 2002).

The ecosystem substitution paradox

A paradox of assigning values to ecosystems is that, unless we take a landscape view, it can be argued that we should replace a less valuable system, e.g. agrassland, for another more valuable one, e.g. a wetland. Costanza et al. (1997), when estimating the value of the world's ecosystem services estimated that wetlands are 75% more valuable than lakes and rivers, 15 times more valuable than forests and 64 times more valuable than grasslands and rangelands (Table 2).

A straightforward economic analysis would thus argue for the replacement of forests and prairies with wetlands. While this physical substitution is, of course, not possible in most instances because climatic and hydrologic variables determine what ecosystem occurs in a particular landscape, on a micro-scale it is not only possible to substitute wetlands for grasslands and upland forests, but it is frequently done to meet regulatory requirements of wetland mitigation in the USA.

Many question whether the created wetland can achieve the same functional and hence 'economic' value as did the original ecosystem at that site. Some argue that these created ecosystems are doomed to failure (Roberts, 1993; Malakoff, 1998) while others are more optimistic that these systems do indeed provide real measurable value that might even exceed what was at the site previously (Young, 1996).

Wetlands of I. R. Iran with International Importance

According to the international terms, I. R. Iran is the birthplace of the Ramsar Convention, which focuses on the conservation and wide uses of wetland habitats and in particular their waterfowl. Most of the places of I. R. Iran fall into the dry or semi-dry category. In such a climate the presence of wetlands, marshlands and water bodies play an important role in the well being of the natural environment, wildlife and human beings. 250 wetlands have been registered in I. R. Iran. The numbers may vary during different seasons and some may also be completely changed every day (Ayaft et al., 2000). In such a volatile situation, conservation of the remaining precious bodies of water becomes a national duty. I. R. Iran has presently designated 22 sites as wetlands of international impor-

Table 2. Estimated unit values of ecosystems (Costanza et al., 1997).

Ecosystem	Unit value $ ha^{-1} yr^{-1}
Estuaries	22 832
Wetlands	14 785
Lakes/rivers	8498
Forest	969
Grasslands	232

Table 3. Wetlands of I. R. Iran with International Importance (Ramsar site #40).

#	Site name	Province	Area (ha)
2IR014	Alagol, Ulmagol and Ajigol Lakes	Mazandaran	1400
2IR012	Amirkelayeh Lake	Gilan	1230
2IR005	Anzali Mordab (Talab) Complex	Gilan	15000
2IR011	Bandar Kiashahr Lagoon and mouth of Sefid Rood	Gilan	500
2IR017	Deltas of Rood-e-Gaz and Rood-e-Hara	Bandar-e Abbas	15000
2IR016	Deltas of Rood-e-Shur, Rood-e-Shirin and Rood-e-Minab	Bandar-e Abbas	45000
2IR022	Fereydoon Kenar, Ezbaran and Sorkh Roods Ab-Bandans	Mazandaran	5427
2IR018	Gavkhouni Lake and marshes of the lower Zaindeh Rood	Isfahan	43000
2IR021	Gomishan Lagoon	Golestan	17700
2IR019	Govater Bay and Hur-e-Bahu	Baluchestan	75000
2IR009	Hamun-e-Puzak, south end	Sistan & Baluchestan	10000
2IR007	Hamun-e-Saberi and Hamun-e-Helmand	Sistan & Baluchestan	50000
2IR015	Khuran Straits	Bandar-e Abbas	100000
2IR013	Lake Gori	East Azarbayjan	120
2IR008	Lake Kobi	East Azarbayjan	1200
2IR003	Lake Orumiyeh	WestAzarbayjan	483000
2IR002	Lake Parishan and Dasht-e-Arjan	Fars	6200
2IR001	Miankaleh Peninsula, Gorgan Bay and Lapoo-Zaghmarz Ab-bandan	Mazandaran	100000
2IR004	Neiriz Lakes and Kamjan Marshes	Fars	108000
2IR006	Shadegan Marshes and mudflats of Khor-al Amaya & Khor Musa	Khuzestan	400000
2IR020	Sheedvar Island	Hormozgan	870
2IR010	Shurgol, Yadegarlu and Dorgeh Sangi Lakes	West Azarbayjan	2500

tance with about 1,480,000 total surface areas in hectares (Table 3).

The Caspian Sea (Figure 1), which is located in the northern I. R. Iran, is the largest lake in the world and is connected to the distant Baltic through canals and the River Volga. It is unique closed water basin, plays the important role in the establishment of the climate. It has rich stocks of rare kinds of fishes, energy-carriers and large potential for development of sea transport.

The coastal wetlands of the Caspian include many shallow, saline pools, which attract a variety of bird life and biodiversity. The Caspian Sea lies on the crossing of migration routes of millions of migrating birds and offers refuge for a number of rare and endangered birds of the world ornitho fauna. About 130 rivers of various sizes drain into the Sea with an annual input of about 300 km3. The main rivers are the Volga (80 % of the total volume of inflow), the Ural (5%), the Terek, Sulak and Samur (total up to 5%), the Kura (6%) and others are small rivers from I. R. Iran. The biological diversity of the Caspian and its coastal zone makes the region as one of the most valuable ecosystems in the world.

The Anzali Wetland complex (37°23 -37°37 N - 49°35' E), is situated on the southwest shore of the Caspian Sea north-east of Rasht and adjacent to Bandar- e-Anzali town on the northern boundary in Gilan province, northern Iran (Figure 1) . The area of the Anzali wetland complex is 15,000 ha (including Anzali wetland 10,990 ha, Siahkes-heem marsh lands 3,650 ha and Selkeh Ab-bandans 360 ha) . 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 con-siderable precipitation (1500 mm) and does not have a dry season. Therefore, the wetland, although it expe-riences some sea water penetration, is a freshwater eco-system. The waterlogged area of the wetland varies con-

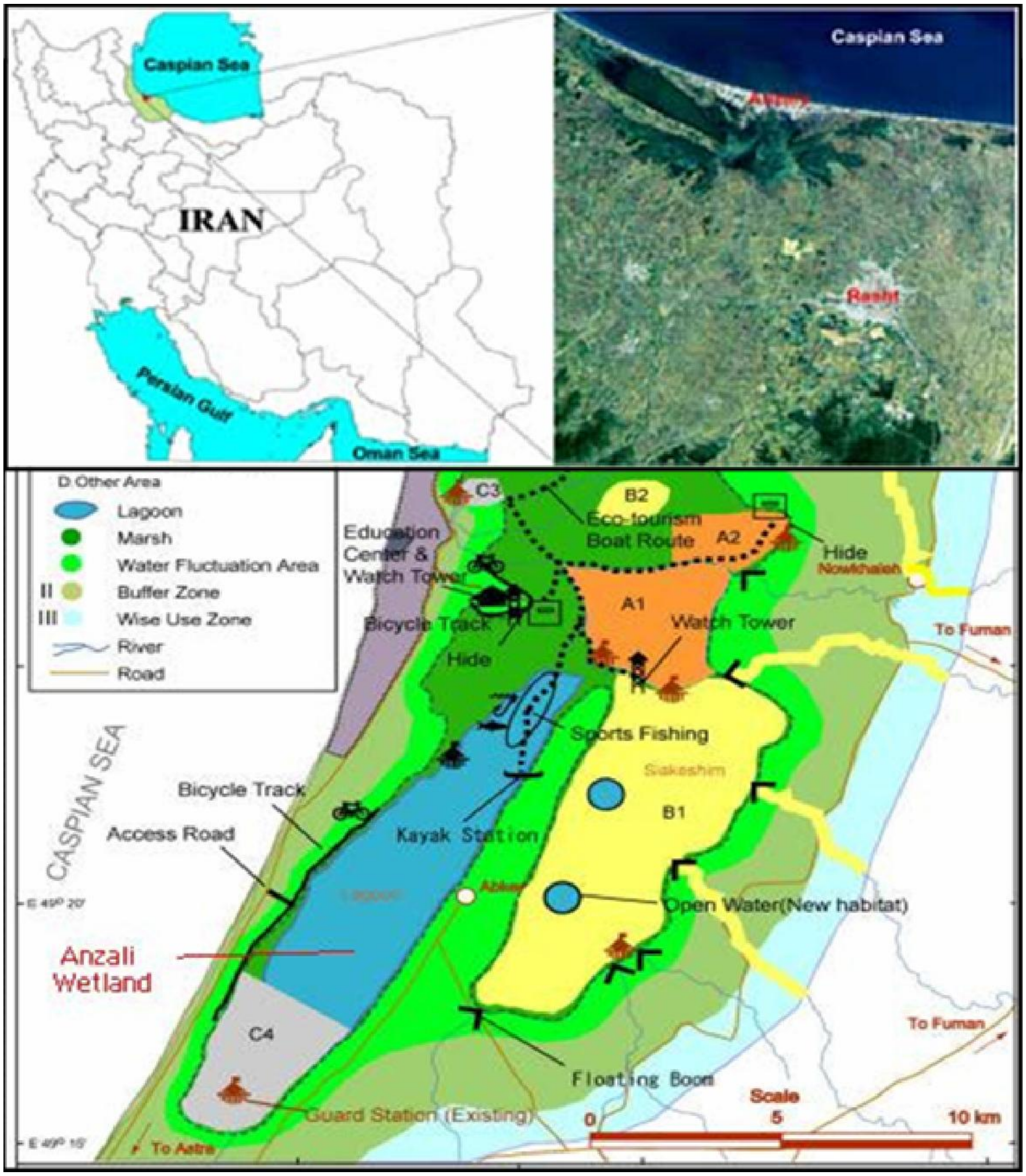

Figure 1. Maps of Caspian Sea and Gilan Province of I. R. Iran.

siderably 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 km ^{2} (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.

Importance of Anzali wetland

Anzali Complex is the most important wetland in the southern Caspian region. This wetland is of great importance due to its diversified habitats. Selkeh and Siahkeshim totaling 4860 ha are protected and 15000 ha of the area is designated as an International Wetland according to Ramsar Convention. Average length of this complex is about 30 km and its average width is about 3 km, some-times exceeding 12 km. Area of this complex is subject to seasonal variations of water. About 60 years ago, it covered an area of 259 km^2. Now, it is only 100 km^2. The depth of Anzali is also subject to changes. The average depth is about 3 m. This lagoon has a passage to the Sea with the width of 426 m. Total precipitation is about 1500 to 2000 mm / year and 11 tributary rivers flow into Anzali Complex. The complex is also connected to the Sea by means of five river streams. Anzali marshes could be divided into three sections: the central section (in the east including Sheyjan), the western section (West wetland) and the southern section (Siahkeshim). All these three water bodies form one unit wetland and although apparently they bear some similarities, they have distinguished specific differences. One of the most specific characteristics of Anzali complex is the presence of numerous islands in the complex namely Shalom-goddess, Mian-poshte, Nover, Galugah, Tardarya and Torabgodeh. The Anzali wetland complex consists of different aquatic and draught ecosystems. It is a good example of a natural and continuous wetland that supports an extremely diverse wetland flora and fauna. In general the wetland supports huge numbers of wintering ducks, geese, swans and coots and the riverine area and the marsh support large breeding colonies of Ardeidae and several species of terns and shorebirds. Anzali wetland supports over 1% of the regional Middle East wintering populations. Several perpetual streams emanating in the nearby Talesh Mountains feed into the Anzali Complex. The entire marsh and lagoon complex drains into the deep- water harbor of Anzali port through the main channel at the northeast end of the main lagoon. The wetland is bordered to the north by sand dunes with grassland and scrubby vegetation and the south by cultivated land (mainly rice) and patches of woodland.

Environmental problems

The Sea level fluctuations have created many environmental problems. For example, the rise in Sea level causes alterations of valuable habitats, due to inundation of the vast coastal areas. Environmental damage resulting from the Sea level rise can be classified as pollution due to damage to the industrial infrastructure and consequent contamination of bio-resources and loss of habitats such as spawning grounds and nesting sites caused by the change in water depth.

Industry, oil production, untreated waste from rivers and transportation has been the source of pollution in the Caspian region. Systematic water sampling in different parts shows contamination from phenols, oil products and other sources. Oil extraction and refining complexes in Azerbaijan are major sources of land-based pollution and offshore oil fields, refineries and petrochemical plants have generated large quantities of toxic waste, run-off and oil spills. In addition, radioactive solid and liquid waste deposits near the Gurevskaya nuclear power plant in Kazakhstan are polluting the Caspian as well. Every year large volumes of wastewater and industrial waste flow into eastern parts of Anzali wetland from the cities of Rasht and Khomam leading to the growth of plants and microorganisms. These plants and microorganisms suck oxygen from the water and the lack of oxygen causes the death of aquatics. There are several point and non-point sources of pollutions into the Anzali wetland, which could be listed as follows:

Rivers pollution

Anzali wetland is located in Gilan Province. There are more than 80 rivers in the Province. The main rivers carrying both sanitary and industrial wastewater and entering to the wetland are about 11 major and 30 minor rivers. This will bring a sum up of about 71 cm^3/s of polluted water. In other words, over six mil-lions cubic meter of polluted water will enter the wetland every day. These will enrich the nutrients as well as increases in the amount of the heavy metals of the wetland. On the other hand, carrying of precipitates into the wetland causes to sediment and decrease the depth. In some parts the depth is reached to less than 0.5 m. The degree of soil saturation of the wetland obviously depends on the magnitude and consistency of its freshwater inflows.

Municipal wastewater

There are 26 cities in Gilan Prefecture. The major ones are: Rasht, Bandar Anzali (Port of Anzali), Talesh, Astara, Loshan, Rood-Bar and Manjil (Figure 1) . The population of the Province is increasing each year, which comes to over 2,500,000 persons at present time. More than half of the population lives in the two main cities of Rasht and Anzali Port. Municipal and trade wastewater of these cities is discharged either indirectly from Pir-Bazar river or directly to the wetland. Not only the wastewater effluent from the houses and trade centers enter directly to the wetland, but also household garbage and solid waste from commercial places have chance to pollute the wetland.

Few investigations showed Pir-Bazar, had the highest amount of coliforms as compared to Gohar Rood and Zarjub. The coliforms for the others are not as high as these three ones. The high level of water in Rasht, no proper disposal of wastes and discharge of municipal and industrial (including sanitary wastewater) wastewater especially food ones were the main factors for high amount of fecal and total coliforms in these rivers. It is obvious that in the rivers which agriculture runoff is discharged, the amount of these parameters is low.

Industrial wastewater

There are more than 30 main polluted factories in Gilan. Among these industries, Wood and Paper Company in Talesh, Wood Fiber Company in Hassan Rood, Iran Poplin textile, Gilan Carpet, Pars Khazar house ware, Zam-Zam soft drink, and several food industries in Rasht are important to mention. The lack of proper wastewater treatment plant in some of these companies will add pollution to the rivers that will end to the wetland. According to the Ministry of Industries and Mines' record, the number of active and in establishment step industries in 2000 in Gilan Province show that the industrial water consumption was two times in 1999 as compared to 1963 (Tashayoie et al., 1999) . At present time it is much higher due to rapid increase in having new industries in the prefecture.

It is necessary to mention that several industrial complexes are located in the province that most of them don't have wastewater treatment facilities and control equipments. Statistics show that about 69% of investments in Gilan Province are done in Rasht (Ministry of Industry, 1995) . It is clear that if the investment in having wastewater treatment plants in this great city were not serious, lots of pollution will enter the wetland from the Zarjub river, which is also one of the most polluted rivers at present time.

Agriculture waste

Due to lots of land used in the area for agricultural purposes, excess emission of nitrogen and phosphorus from the area will bring excess nutrition to the wetland. Nutrient enrichment due to wastewater runoff of farms especially from rice-fields including fertilizers, pesticides, herbicides had caused eutrification phenomena in some parts of the wetland such as Siah-Keshim. This has also produced distribution of gases such as hydrogen sulfide and methane in the area, which resulted in anoxic and anaerobic conditions that disable activities of any fishes in the water.

Mines

Gilan Province has good conditions for mineral materials extraction including industrial soil ($SiO_2Al_2O_3 \cdot xH_2O$), oragonite ($CaCO_3$), building stone, copper, oligist (Fe_2O_3), sillis (SiO_2). In the Prefecture, there are 30 active mines, 20 in establishing step, 10 in preliminary permission and 5 in investigation state. Most of the mines are located in the east of Loshan and in the West of Amlash, Masuleh and Khotbeh-Sara in Talesh city. There are few investigations on the emitted pollution from the mines to the rivers and the wetland, which is required for future investigations.

Hospitals

There are many hospitals in cities of Gilan Prefecture. Unfortunately like other hospitals in I. R. Iran, not much serious control on hospital hazardous waste has been done. Rasoul-e-Akram is one of the hospitals in Rasht city. Its wastewater is being analyzed by Gilan Province's DOE local office. They have found out that its coliforms are high at present time. The other results are not given out, yet. It is also clear that some of the data could be confidential.

It is important to mention that the routine analyzed parameters from the most hospitals in Gilan Prefecture are conductivity, suspended solids (SS), total dissolved solids (TDS), pH, acidity, alkalinity, total hardness, Ca, Mg, K, Na, Cl, sulfate, ortho-phosphate, total phosphate, N -ammonium, nitrite, nitrate, dissolved oxygen, biological oxygen demand (BOD), COD, chlorine, coliforms, E-coli. But it is suggested that hazardous substances such as heavy metals and radioactive materials should be considered in their parameters.

At this moment, the data is not available to be included in this paper. The author wishes for more research in this area and do hope to include the results in near future.

Other sources

Besides of the above main sources of pollution there are others, which are worth to be investigated that are discussed in the following paragraphs:

Discharging used oil of ships: Spread layer of used oil on the wetland because of the navigation in the Sea and wetland. It is obvious that oil is lighter than water and prohibits entering sunlight into water depths. This causes to reduce photosynthesis that will have unwanted problems in the coming years. Although, this may not be considered as a point source of pollution to the wetland, but it can be assumed to be as non-point source one.

Construction of bridge on the wetland: One of the main impacts and hazards for the wetland's life is the plan of bridge construction. Although this may control tra-ffic jam in Anzali city port, but this will attract lots of transportation in the area by the tourists especially in springs and summers. This matter has been one of the important issues in the country for many years. Some parts of mentioned bridge were constructed in the previous years (Figure 2).

Gilan local DOE had many meetings with environmenttal experts including Environmental Engineering Department (EED) of Tarbiat Modarres University (TMU) regarding the danger of this plan on ecosystem life of Anzali wetland. Fortunately, the Iranian Government has recently accepted to change the construction of the bridge from the wetland to another safe place.

Biological or ecological notes

Disturbing the ecological condition of the Caspian Sea has caused degradation its biodiversity. It is important to mention that Anzali wetland is one the main conserve areas in the world, because it is vital for many biological communities:

Birds: 145 species of migratory birds are known in Iran. Among them 77 species, or 53% can be seen in the Anzali wetland. In 2005, about 700,000 migratory birds from Siberia and other parts of the world, mostly ducks, geese, swans and coots, were observed in the wetland. The wetland is the most important wintering area in Iran for *Phalacrocorax pygmaeus* (Pigmy Cormorant), regularly hold-

Figure 2. Anzali Wetland and *Azolla Pinnata* growth on the wetland water surface.

ing more than 500 in mid-winter. *Pelecanus onocrotalus* (While Pelican), *P. crispus* (Dalmatian Pelican), *Botaurus stellaris* (Bittern) and *Anser eryhopus* (Lesser White-fronted Goose) are occasional winter visitors and *Oxyura leucocephala* (White Head Duck), *Charadrius asiaticus* (Caspian Plover), *Vanellus gregarious* (Lapwing) and *Gallinago media* (Common Snipe) have been recorded on passage. Other noteworthy birds include *Cygnus columbianus* (Bewick Swan), *Athya nyrica* (Ferruginous Duck), *Branta Ruficolius* (Red Breasted Goose) and *Athya marila* (Scaup), all of which are endangered in Iran.

Plants: The dominant vegetation throughout much of the Anzali wetland consists of vast beds of *Phragmites australi*s, which in places grows to six meters height. Due to falling levels of the Caspian Sea in the late 1960s, a rapid expansion of the Phragmites reed began and by the early 1980s, large parts of the main wetland were covered. Together with increased pollution and eutrophication, the situation had become so serious that methods of control were considered. The recent rapid rise in water level in the wetland stopped the expansion of *Phragmites* and re-created open water areas. The new water areas support vast beds of the water lily *Nelumbo nucifera* var. *caspica*, and a very rich growth of other floating and submerged vegetation.

Wetland plants in the Anzali wetland can be broadly classified into four groups:

(i) Submerged plants.
(ii) Floating plants.
(iii) Emergent plants.
(iv) Land plants.

There are 9 species of submerged plants of which Potamogetons are widespread; 11 species of floating plants, such as *Trapa natas*, *Lemma minor* (Duckweed) and *Nelumbium capsicum* (Lotus); 11 species of emergent plants, of which *P. australis* (Common Reed) and *Typha australis* (Cattail) are dominant; and 6 species of dry land plants.

Azolla pinnata from the Southeast Asia into the Anzali wetland and its rapid growth especially in warm climates. Regarding the Azolla, although; this aquatic plant was meant to be quarantined in a small pool, it escaped and found its way into the natural environment where it flourished. Now this species (which is quite useful in Southeast Asia) has become a pest, competing with the other native species for vital resources such as light and nutrients. It has many considerable characteristics for nitrogen stabilization and can be used as a fertilizer especially in rice-fields. It can stabilize 3 kg nitrogen in each hectare. But rapid growth and distribution of Azolla mass on the water surface has prohibited sunlight pass through that has caused decreasing in T, gas transfer, DO and suspended food in the water and main problems in the wetland ecosystem. Figure 2 indicates the growth of Azolla on the surface of the water on the wetland.

More ecological information on the weed than is presently available would be very useful to understand the nature of invasions and facilitate management efforts. Plant phenological data would be highly informative for all management approaches. Baseline pre-release data on planned control sites and release sites will be valuable in monitoring the post-release impacts of biocontrol agents.

Fish: The outlet of the Anzali wetland is connected to the Caspian Sea, making it an important spawning ground for many fish species. Anzali wetland and its tributaries are habitat of 12 families, 34 genus and 39 species of fishes, some of which are migratory. On the other hand, 39 of the 49 fish species in the Anzali wetland are resident. Some species are only found in the Anzali wetland and not in any other part of the south Caspian: *Alosa caspia knipowitschi* (Enzeli Shad), *Barbus brachycephalus caspius* (Caspian Barbel), *Leucaspius delineatus caucasicus* (Caucasian Verkhovka), *Perca fluviatilis* (River Perch), *Scardinus eryhrophthalmus* (Rudd), *Nemachilus angorae* (Stone Loach), *Proterorhinus marmoratus* (Tubenosed Goby) and *Pelecus culteratus* (Sabre Carp).

DISCUSSION AND RECOMMENDATIONS

The evaluation of wetland quality is a challenging and complicated task. In many circumstances and for a host of different reasons, environmental professionals, land use planners, resource managers and others are faced with the need to assess wetland health. Since the means for engaging in meaningful wetland assessment are not fully developed, are not accessible, or are not affordable, the evaluation of wetland quality has been widely overlooked and omitted. As a result, land use planning and resource management decisions affecting wetlands are frequently being made with incomplete and inadequate information.

International Anzali wetland is saddled with masses of pollutants and waste discharged into it, leading to its gradual degradation. Human sprawl, release of urban waste into the water and excessive growth of invasive plants have all created problems for the internationally significant wetland and harmed the biological capabilities of aquatic creatures living in it. As reported by Iran, Anzali wetland is one of the most important marshlands along the Caspian shores which plays a key role in regional economy, tourism and job generation. The wetland, home to a variety of saltwater flora, is important for the control of flooding and enhancing groundwater sources, not to mention how crucial it is for regional fishing and hunting. Anzali wetland is the breeding ground of valuable fish like carp and salmon as well as the natural habitat of unique animal and plant species.

The river has for many years been carrying waste, sewage and effluent all the way from the cities of Bandar Anzali, Fouman, Some'eh Sara, as well as the central districts of Rasht, Khomam, and Kouchesfahan into the wetland. 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. 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.

Considering rapid population growth and migration, higher accumulation of communities is noticed in coastal areas. This is especially true with the coastal areas of the Caspian Sea. Climate change, Sea- level rise and cyclone damage will increase vulnerability. The key to wetland survival is engagement of local communities in their sus-tainable management, with accessible technical support from the scientific community particularly in baseline as-sessment of the resource, monitoring and rehabilitation where required.

The Caspian littoral countries are under the severe problems of Sea levels fluctuation, overfishing, threats of invasion by alien species; and riverine, domestic, industrial and radioactive pollution. Most of the Caspian coastal states are developing countries and only through regional cooperation and collaboration these problems could be faced. Whether a legal status of a Sea is conferred to the Caspian or that of a lake, the Caspian states are moving towards developing a common policy for the rational exploitation and conservation of the biological resources and also for the monitoring and abatement of the various types of water pollution. Besides a close regional cooperation, an international assistance is needed for the formation of general policy, environmental legislation, strengthening existing institutional and technical support in the fields of Integrated Coastal Zone Management (IC ZM), sturgeon fishery, protection of biodiversity and monitoring and management of various types of pollution.

In addition, prevention of natural crisis relating to changes in Sea level and its hydrodynamic impact requires consideration of the sensitivity of specific coastal regions. Several development applications (commercial, industrial, residential, agricultural) must be reconsidered and the limit of marine action must be identified. It is necessary to construct structures to protect coasts using a sound engineering strategy.

Finally, similar to the establishment of a long-term wetland reference site database, future wetland assessment projects would contribute to the continued building and refinement of the wetland biological attribute database. Metric attributes as described in the sections on wetland vegetation, aquatic macro invertebrates, and avifauna need to be expanded to include species not captured in surveys for this project and attribute values must reflect the most accurate professional judgement as possible. The further development of this biological attribute database would qualify as a high priority research project with significant applicability and benefits.

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