

Caspian Sea, Leading Threats in terms of Pollution and Hydrological Crises

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ABSTRACT: Caspian Sea, largest enclosed inland body of water in the world, has been constantly affected by different pollution sources due to its special ecological properties, geographic limitations and different onshore/offshore human activities. The most important pollution source of Caspian Sea is daily extraction and transportation of crude oil and gas. In addition to different natural and man-caused contaminations threatening this water body, numerous hydrological threats are influencing this strategic sea. Depth change of this lake is one these threats. In last century the lake has experienced three periods of rapid decrease, slow decrease and slow increase in depth while recent observation shows the reduction of water depth again. These water depth changes had several effects on this enclosed sea that caused pollution enhancement in many ways. The purpose of this paper is to provide a clear description of quality and severity of threats against this valuable lake that could be an important step in identifying threats and potential opportunities in this field.

Keywords: Caspian Sea pollution, depth change, Caspian Sea water level, hydrological threats, Natural contaminations

INTRODUCTION

Industrial development and irregular increasing population in rural and urban area, followed by expansion of agricultural area and also fertilizers and pesticides consumption and as well as excavation and extraction of oil, led to large amount of industrial and domestic wastewater and agricultural runoff that discharge into aquatic ecosystems. Change in water cycle and climate within the watershed have a high impact on the sea level. At the same time, non-sustainable agricultural practices, especially on the river Volga, and human-induced change in water regime contribute greatly to the sea level rise too. Fluctuations of sea level is one of the most important environmental problems, which has reached the scale of a serious social and economic crisis affecting the population of the littoral countries, especially in northern part of the Caspian Sea (Zajtsev and Pavlova, 2005) [1]. The impact can be both chronic (long-term) and acute (shortterm). A long-term impact is historical natural sea level fluctuations, which can be attributed to changes of climate and river discharge into the Caspian. Acute (short-term impact) is seasonal or wind induced changes of level. Among the most important components of the water balance of the sea having, as was indicated, an effect on the course of the sea level and its probable fluctuations are nonreturnable withdrawals and water losses in the Caspian basin. The volumes of nonreturnable withdrawals of the runoff that were taken into account by a number of investigators (Asarin, 1997) [2]. As large amount of industrial wastewater is produced every day in all countries. Large amount of money is spent for treatment of this wastewater. The industries do not like seriously to spend the money because they will not get any profit from that. In another words, industries do not get back any money that they expect on treating their own wastewater.

These wastewaters containing different chemical compound including heavy metals and organic contamination with high half-life [3]. Caspian Sea is the largest enclosed aquatic ecosystem in the world that has been affected by population increment and industrial development of countries around it and has been exposed to dangerous situation. Although the roll of these countries in polluting the Caspian Sea is not the same, but under the influence of water flow from northwest of the lake toward its south and southeast, pollutions spread all over the sea [4]. On the other hand, rising in water level of Caspian Sea submerged thousands kilometers of coastal areas, oil fields and agricultural lands, ultimately contaminating water environment [3,5].

Because of increasing amount of chemical pollution, as by-product of human activities, poured into aquatic environment and stability and non-biodegradability of these pollution, great deal of attention has been paid to them [6].

1. Study and review

Caspian Sea is located at south border of Asia and Europe, north region of Plateau of Iran and among five countries of Iran, Azerbaijan, Turkmenistan, Kazakhstan and Russia. The length of the lake is about 1200 km and its average width is 330 km (240 – 566 km) [7]. It has 6400 km coastline, which 990 km of it, from Astara to Atrak River, are Iran's coastline and other 5408 km are others'. Total Catchment area of Caspian Sea is 3.5 km^2 that spread between Iran, Azerbaijan, Turkmenistan, Russia and part of Turkey. Figure 1 shows this catchment [7].

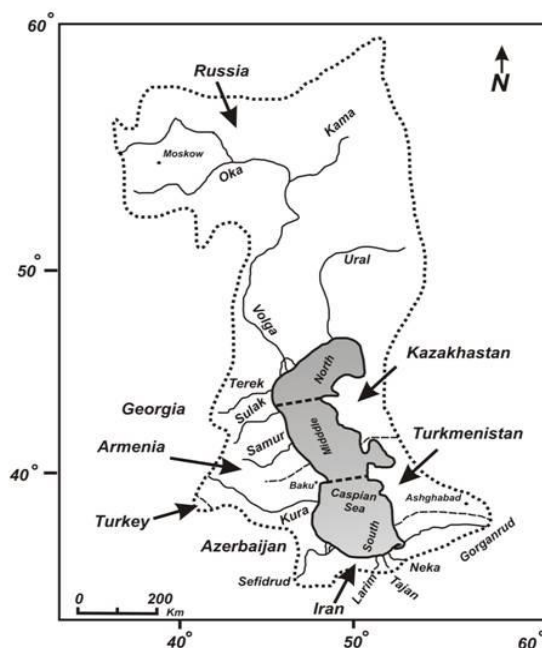


Figure 1. Catchment of Caspian Sea and geographical location and rivers entering it

Important rivers entering from different coastal regions are as follows [7]:

- Volga and Ural rivers, entering from northern coast, supplying 87% water of the catchment. Volga River allocated 1.4 million km^2 of total catchment to itself.
- Rivers entering from the western coast including Terek, Sulak and Kura, providing 7% of water. And
- Rivers of southern coast including Sefidrud, Aras and Haraz, that provide 5% of catchment water.

Southern regions of Caspian catchment with area of about 256000 km^2 is one of the vast watersheds of Iran that starts as a band from northwest of Azerbaijan and after passing the north slope of Alborz mountain chain, stretches toward northwest of Khorasan. In Qezel Ozan river watershed, part of this catchment stretches to Kurdistan and Zagros mountain chain [8].

Caspian catchment is too steep and has the maximum altitude difference in Iran (5500 m). Around 866 large and small rivers flow in this region that most of them are originated at height of northern Alborz mountain chain. Table 1

provides an accurate data on areas of Caspian catchment and consequently the importance of pollutions in the water they supply.

Table 1. Distribution of Caspian Sea catchment in different regions

River	Watershed area (km²)	Country
Volga	1402010	Kazakhstan and Russia
Sulak	57499	Russia
Terek	13370	Russia
Rivers between Sulak and Samur	9020	Russia
Samur	4430	Azerbaijan
Rivers between Samur and Kura	15980	Azerbaijan
Kura	188040	Iran, Azerbaijan, Turkey and Armenia
Rivers between Kura and Astara	12280	Azerbaijan
Rivers between Astara and Anzali	3200	Iran
Rivers of Anzali lagoon	3350	Iran
Sefidrud	67000	Iran
Rivers between Sefidrud and Gorganrud	13200	Iran
Gorganrud	26700	Iran
Atrak	26700	Iran and Turkmenistan
Caspian catchments with almost no discharge		
Area between Volga and Terek	129800	Russia
Area between Terek and Sulak	4200	Russia
Area between Atrak and Ural	822040	Turkmenistan, Kazakhstan and Uzbekistan
Area between Ural and Volga	150400	Kazakhstan and Russia

1.1 The status of Caspian Sea pollution

It seems that Iran's northern neighbors have greater role in Caspian Sea pollution and impose all kind of pollutions into this sea. But Iran's share in the Caspian Sea pollution is undeniable; most of the cities located in coastal area discharge their untreated wastewater into the sea. As population in three northern state of Iran being incremented, marine water resources utilization, wastewater discharge and pollution emission has been increased. On the other hand, existence of several coastal port (such as Anzali, Nowshahr, Fereidoonkenar and Amir Abad) leading to ships and oil tankers transportation, fossil fuel power plants and oil storage tanks in Neka and other human activity such as tourism followed by high traffic vehicle, development and establishment of domestic areas, development of agricultural lands and factories establishment, resulted in discharge of huge amount of pollutions in Caspian Sea. These events endanger the Caspian Sea ecosystem. Therefore, industrial monitoring and prevention of pollution discharge, especially heavy element, into southern coast of Caspian Sea is necessary. According to World Bank report, the direct discharge of untreated wastewater into Caspian Sea is one million cubic meters. Most of these pollutions are related to extraction and refinement of oil and minerals [9].

According to World Bank report, Neville estimated the mean annual discharge of oil, sulfide and chlorine as 60000, 240000 and 400000 ton, respectively.

Due to discharge of human sewage into the rivers leading to Caspian Sea, microbial contamination of this sea is too high and in some areas it is 100 times the permissible level [10]. One the most important sources of pollutions are different industries located in vast watershed of Volga River; Most of these industries don't have any treatment system. Thus, Volga River discharges human sewage, agricultural runoff and industrial wastewater into Caspian Sea along with itself [11, 12]. The algae growth is measured in different seasons. The growth of algae in the Caspian Sea in the chart below, according Figure 2.

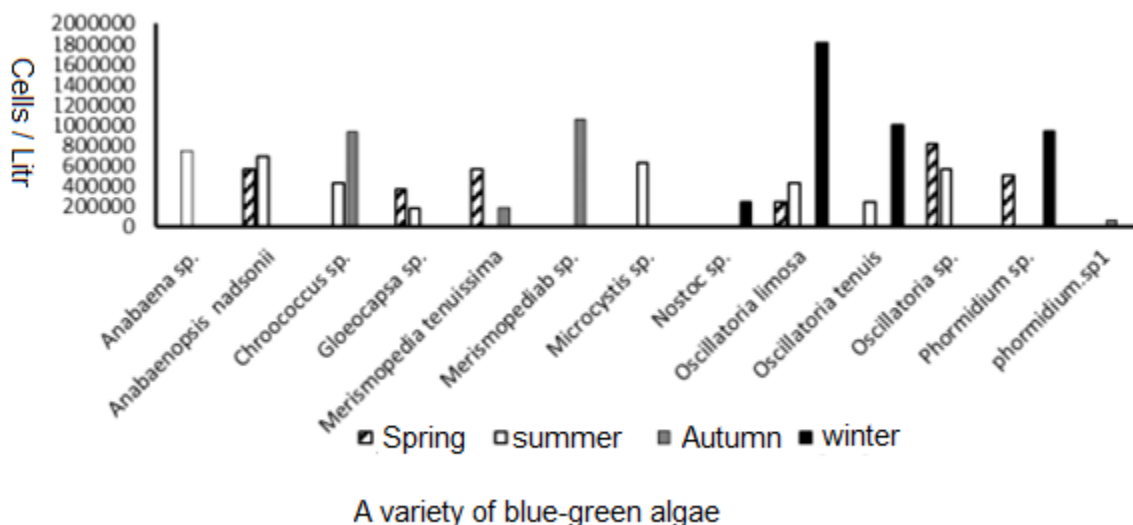


Figure 2. Algae growth charts

1.2 Changes in Caspian Sea water level

Since the beginning of systematic observations of Caspian Sea water level in 1830, 4 period was distinguished [13]:

- Relatively stable period between 1830 and 1929.
- Rapid reduction of 1.7 m in 1930 to 1941.
- Slow reduction in 1942 to 1977. At the end of this period the water level was at its lowest point in the last 160 years, 29 m.
- Slow rising since 1978

The reduction of 3.5 m between 1830 and 1977 has been almost compensated with 2.55 m rise of water level in last period. But, recently, some reports show the reduction of Caspian Sea depth. Gilan Regional Water Co. CEO stated that "Studies shows 80 cm reduction of Caspian Sea water level that is concerning" [14]. Institute of Water Research reported that the Caspian Sea water level was decreased 8 cm in first half water year of 1391-1392 compare to the same period of last year [15].

Water level changes could be due to one or more factors including: climate changes, tectonic processes and human activities.

Bruckner believe that increasing and decreasing of Caspian Sea water level happen every 30-35 years in correlation with alternation of heat and drought. The greenhouse effect is a key factor in water level fluctuations in vast catchment of Caspian Sea. According to another theory the climate portion in water level changes is 85%. In addition to periodic changes, sudden changes can alter the morphology of coast and transform them to unusable areas [13].

Aggregate extraction from river estuaries resulted in seawater penetration and progression in soil that caused morphologic change of coast and changes in plant species in Gilan coast. Most of the dominant vegetation in these areas is destroyed and other salt-water resistant species replaced them. Aggregate extraction from sand dunes behind the coastal line caused instability of coast and salt water progression in soil, water level changes and deepening and lengthening the location of wave breaker. Also, aggregate extraction from coastal line caused changes in sea water level which exposed large parts of coast to erosion and push back shoreline. Figure 1 shows the water level changes of Caspian Sea between 1830 and 2008 [13].

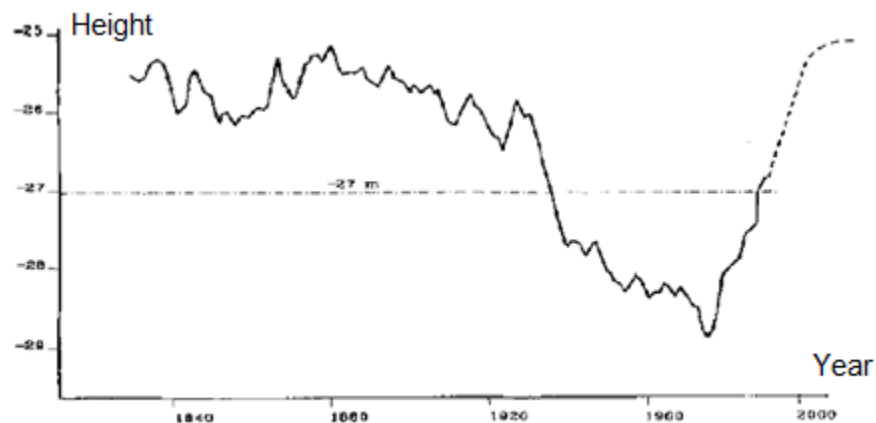


Figure 3. The water level changes of Caspian Sea between 1830 and 2008

1.3 The usage of satellite altimeter data in the monitoring of annual fluctuations in water level of the Caspian Sea

It's been more than 10 years that satellite altimetry have been used as a successful method in monitoring water level changes in continental surface water such as seas, lakes, rivers and recently wetlands [16, 17]. Several bases for determining seas water level have been developed. The most mention ones are reference ellipsoid, local bases and free water surface (the geoid computation) [18]. Figure 3 and figure 4 are accurate results that obtain with satellite altimetry method.

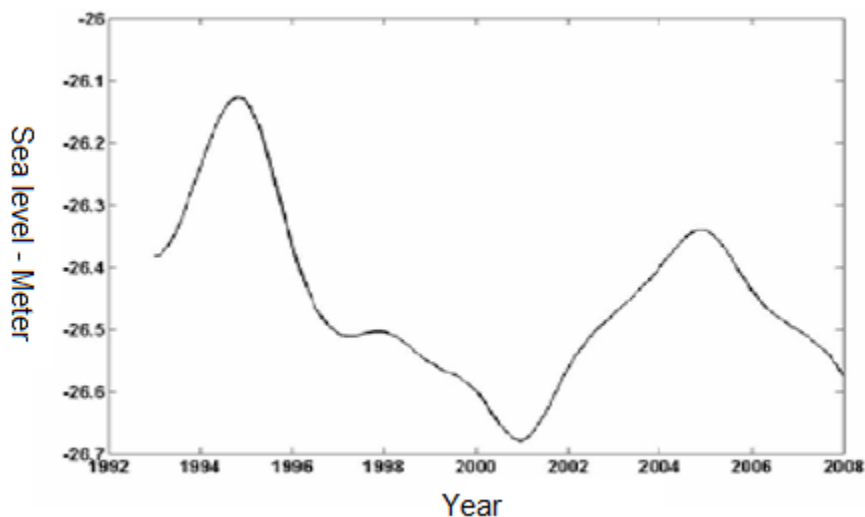


Figure 3. Annual changes of Caspian Sea water level between 1993 and 2008

Figure 4 gives more accurate and visual perspective of water depth in different poit of Caspian Sea.

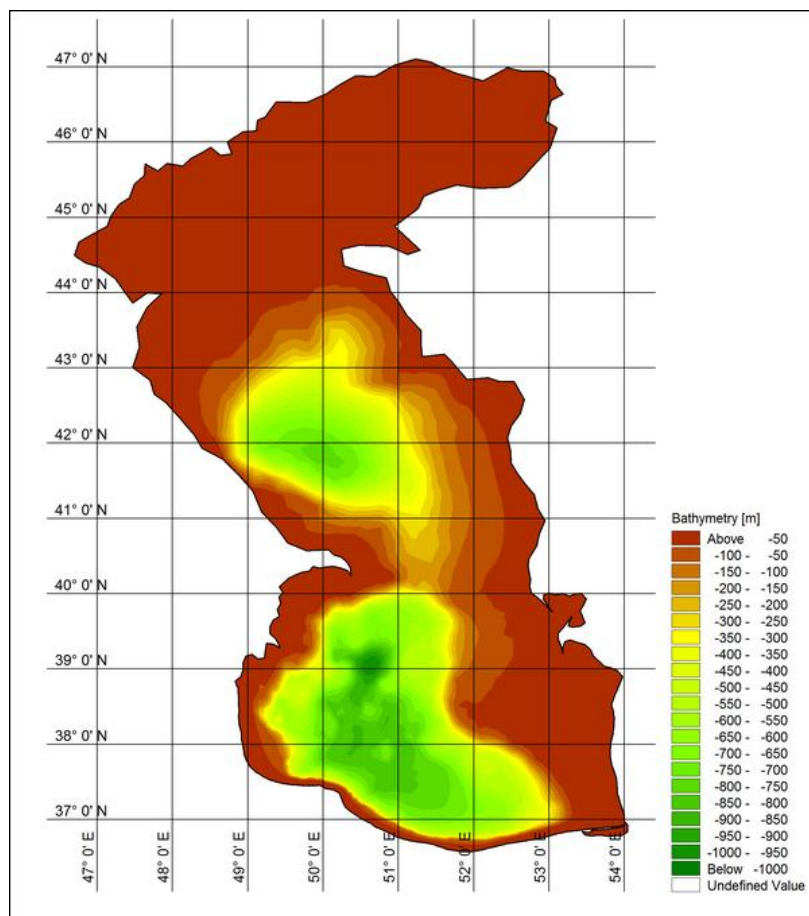


Figure 4. Caspian Sea water level

1.4 Caspian Sea contamination and its approaches from the perspective of international environmental law

Caspian Sea has special legal status that concept such as the territorial sea, the surveillance of the exclusive economic zone and continental shelves are not posing in this case. In the term of international law, Caspian Sea is considered as a complete enclose sea, therefore, regulation of sea law, authorized in 1982 convention, are not adaptable this water body. There is no mention of bed, subsoil, operation and ownership of mineral and hydrocarbon resources and reserves in any of pervious contracts and agreements related to Caspian Sea. Even exploitation of biological resources from this sea doesn't have clear legal status, except within the limitation of 10 miles of shoreline [18]. Considering the special situation of Caspian Sea in the terms of unclear legal status, geopolitical issues and international law as an enclosed sea, how the issues of environmental protection will be solved in it [19].

Caspian Sea littoral states should not exploit its natural resources unilaterally. Until establishment of a comprehensive legal system, following the previous agreement between Iran and Soviet Union in 1921 and 1940 and allegiance to international law of environmental protection by littoral states is necessary [20]. In addition, the enjoyment right of permanent protection of natural resources, recognized in international documents, should be respected within the limitation of international and environmental protection law [20].

Conclusion

Caspian Sea enclosement, extensive exploitation of its natural resources, pollutant accumulation and severe changes of water level of this sea, put it in an ecological crisis. Prevention of discharge and emission pollutions requires the cooperation of littoral states for a common interest. Cooperation of the Caspian Sea region countries in protecting its environment and purification can attract international support.

There are some effective strategies in this context: usage of international and local conventions related to marine and environment pollution in order to access multilateral agreements with international companies participation, creation of institutional mechanisms in order to improve and increase the local association of environmental studies in Caspian Sea area, developing a comprehensive legal system to control the rights and duties of littoral state of Caspian Sea in proper utilization of resources with consideration of requirement international environmental laws, multilateral agreements between littoral state of Caspian Sea on local cooperation and data transfer at the event of environmental incidents, give an especial attention to observe, monitor and predict changes in water level of this vast water body and prediction of short-term and long-term effect of this phenomena.

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