

*Review*

# Review of pollution sources and controls in Caspian Sea region

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Experts believe that the release of over one billion cubic meters of industrial, chemical and household wastewater into the Caspian Sea per annum has polluted the water, and reduced the level of oxygen jeopardizing over 400 aquatic species including sturgeons. Extraction and transportation of oil in the Sea are one of the pollution sources in the Seawater. Caspian Sea contains about 100,000 million barrels of oil. It also contains over 35,000 million cubic meter of flue gas. Daily extractions of crude oil and gas and transportation of them are the main pollution sources of the Caspian Sea. Many trucks for charring oil from ports along the Caspian Sea are considered as point and nonpoint sources along the seaboard. In addition, many ships, which are navigating in the Sea, are emitting pollution to the Sea. Many cities and industries surround the Caspian Sea. Pollution from these cities and industries enter the Caspian Sea either directly or through rivers. The purpose of this paper is to look at the benefits of environmental management strategies in pollution prevention such as waste minimization and clean technologies. This minimizes the environmental problems due to waste generation and eliminates the cost of treatment and disposal of the waste. The benefits of the environmental management program along the Caspian Sea will ensure the clean water and the better environment of the Sea.

**Key words:** Caspian Sea, pollution, oil, waste minimization.

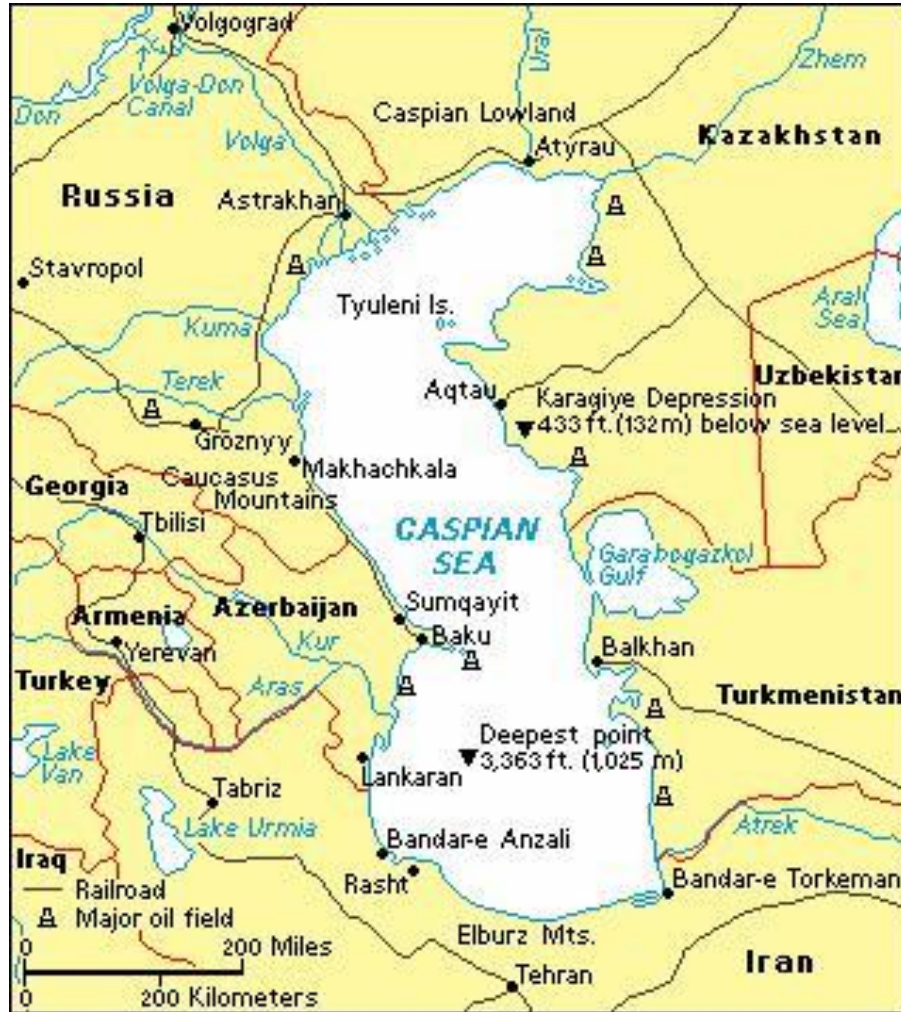
## INTRODUCTION

The Caspian Sea is the largest inland body of water in the world (Map) (Figure 1). It washes five countries: Azerbaijan, Iran, Kazakhstan, Russia and Turkmenistan. A significant part of it is located in the Caucasus, shared by Azerbaijan and Dagestan. The water level of the Caspian Sea is currently about 26.5 - 27 m below the Baltic Sea level. The level has fluctuated from 6 to 7 m during the past few centuries and about 13 m over last 500 years (State Committee of the Azerbaijan Republic on Nature Protection, 1993). Historically, the sea accounted more than 90% of world's sturgeon and caviar output. Additionally, it has abundant oil and gas deposits and they are exploited both on- and off-shore. Major environmental issues related to the Caspian Sea are the impact of water level fluctuation on coastal settlements, decline in sturgeon populations and water pollution from oil and gas operations, industry, households and agriculture. The water level rose over four meters between 1978 - 1995, causing severe damage to nearby territories, populations and infrastructure. About 807 km<sup>2</sup> of land was inundated in Azerbaijan. An additional 460

km<sup>2</sup> will be flooded if the sea level rise to -25 m (State Committee on Ecology and Control of Natural Resources Utilization, Azerbaijan Republic, 1998).

And because the Caspian Sea is non- tidal and confined, the sea's ability to absorb pollution is less than that of an open ocean. Additionally, oil spills can remain localized, becoming a greater threat to marine life than if they were broken up and dispersed by a rough sea. These make certain aspects of offshore drilling in the Caspian unique. Oil companies need to be careful about using data from the North Sea or other less confined seas in environmental impact assessments. Environmental groups call for a lower level of pollution than in other offshore drilling areas in order to protect the sea's fish and marine life from what they believe will be higher concentrations of pollutants (Cox and Norlen, 1999).

The sea level rise has resulted in significant economic, health and environmental damage to Azerbaijan and Dagestan. Communities in affected areas have suffered from increased humidity and dampness; drinking water quality has deteriorated due to the salt water intrusion;



**Figure 1.** Map: The Caspian Sea, the largest body of water in the world that is surrounded by land, lies between Europe and Asia

communications infrastructure has been significantly damaged; flooded agricultural lands and damage to sturgeon hatcheries and fish processing industries have deepened unemployment and poverty. The rising sea has also caused the secondary pollution of marine water from oil fields either through direct flooding or water table rise and ground water seepage. While in recent years the sea level has slightly declined, it was estimated that it will continue rising over the next two decades. The reasons for sea level fluctuations are not well understood. Presumably both natural and anthropogenic factors affect it. 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). The impact can be both chronic (long-term) and acute (short-term). 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).

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. However, it is a real requirement for the environmental protection agencies to obey certain constituent's level of wastewater discharges. Cleaner production resulted in the conservation of raw materials and energy. It ensures the elimination of toxic materials, and the reduction of quantity and toxicity of all emissions and wastes from the product materials. The clean technologies have been practiced in process plant, recycling, process modification, and improved plant operation and input substitution. The clean products have been obtained by many ways such as redesigning, and modification of the process and changing chemicals used to less hazardous ones. Many cities, industries and factories surround the Caspian Sea of the I.R. Iran.

Pollution from these cities and industries enter the Caspian Sea either directly or via rivers. Several rivers that carry the wastewater from cities and industries are first entering the Anzali marsh (wetland) that is located in the west part of the Caspian Sea. Cleaner production resulted in the conservation of raw materials and energy. It ensures the elimination of toxic materials, and the reduction of quantity and toxicity of all emissions and wastes from the product materials.

By the definitions of the worldwide organizations such as UNEP, the objectives of the cleaner production programs are given as follows:

- i) Worldwide awareness of the preventive environmental production strategy should be increased.
- ii) Insuring development of cleaner production programs and activities for the cleaner production expansion by helping government and industry.

Chemical coagulant, synthetic, and natural polymers have been shown very effective in removing both color and Chemical Oxygen Demand (COD) from pulp and paper wastewater (Ganjidoust et al., 1997). Enzymatic treatment of bleached pulp and paper wastewater has been shown to result in high chloroorganics and absorbable organic halides (AOX) removal efficiency (Ganjidoust et al., 1996).

Several investigators have shown good removal rate of COD from similar type of wastewater. Ferguson (1993) has shown that about 70% of COD from bleaching wastewater were removed using aerobic reactor. Koriss (1993), in his paper called: "Water Protection at the Pulp Industry" has shown that the full size aerobic treatment plant in Austria in 1992 had over 90% of its COD removed. Eilbeck and Mattock (1987) have reported from 85 to 92% and 40 to 60% reduction in color and in COD respectively. Several aerobic batch studies have been shown a reduction of about 70% in the COD of either alkaline or cellulose fiber or combine of them (Ganjidoust et al., 1994). Oil Pollution is another pollution source along the Anzali Port and Chaloos City is the ship, which carry mechanizes and oil. Oil burns cause other oil pollution problems in the Sea. This may happened due to accidental fire or by fight. Persian Gulf War in 1991 is an

example of the oil burns due to fight. In January 1991, the invasion of Kuwait by Iraq resulted in firing over 900 million barrels of oil which was burned over nine months in 8 cities of Kuwait. In addition to air, land, birds, animals and agricultural pollution that were recorded due to the invasion, sea pollution was also mentioned. Over one million of crude oil has been entering the Persian Gulf and then into the Indian Ocean. This has caused a lot of problems for fishes. Marine organisms were strongly damaged by the War. Lots of sea birds could not fly because of being polluted with the oil (Badkoubi, 1994).

## **DISCUSSION**

In this section, the waste minimization program that has been seriously applied is discussed into present situation, applied cases and future program.

### **Present situation**

The Caspian Sea is exposed to environmental crises caused by man and nature. Point and non-point sources of pollution from cities and industries into the sea are not well identified and controlled. Human activities in the Sea have to be environmentally controlled.

### **Oil pollution**

Oil pollution sources in the Seawater are mainly due to the following:

- a) Daily extraction and transportation of oil in the Sea.
- b) Oil tankers accidents.
- c) Oils spillage from the oil tankers.

Physical, chemical and biological processes of the oil in the sea will cause many environmental pollution and problems. The oil in the sea will spread very fast on the sea surface. Portion of that will evaporate and some will be dissolved in the water. Oxidation and photochemical reaction will take place at the surface of the water. Sedimentation of the heavy oil by any means to the bottom of the sea is another way of polluting the plants in the sea. Biodegradation of oil by microorganisms may also happen. There are many means of collecting oil pollution from the sea, but expensive. It is very important that the oil pollution prevention be practiced in the sea. It is wiser to control the oil pollution from the oil tanks, which carry oils from Anzali Port every day. It has been observed that many oils are spread on the surface of the streets in Anzali City, which are close to the seashore. This pollution will enter the Sea by any means.

### **Industrial pollution**

Caspian Sea is located in north part of the Islamic

Republic of Iran (I.R. Iran). Three prefectures; Gilan, Mazandaran and Gorgan surround it. Many cities and many industrial factories surround the seaboard. Astara, Anzali, Rasht, Lahijan, Ramsar, Chaloos, Babolsar, Sari, Shahi, Mahshahr and Gorgan are the main cities, which are also industrialized in the seaboard area. Industries such as wood and paper, textile, chemicals, food products and foods processing, electronics, and fish processing are the major ones in the surrounded sea-board cities. Among these industries, Wood and Paper Company (CHUKA) in Talesh city, Gilan, Wood Fiber Company in Hassan Road, Gilan, Iran Poplin in Rasht, many food products and food processing industries in all of them are pollution sources for water as well as atmosphere. However, the industrial sector in the Islamic Republic of Iran is young in the field of environmental control technology envelopment and application.

### **Applied waste minimization program**

Not much work has been done for the oil minimization in the Caspian Sea. Waste minimization program has been applied to many industries two companies in which the waste minimization is practiced are discussed in this section. One having both line of wastewater (fiber, and alkaline wastewater) and the other has only fiber wastewater. The results of the program applied in these two industries are given as follows:

One of the main successes in waste minimization management is to try to use fewer chemicals in the process. This has been practiced in Iran Wood Fiber Company. The paraffin used in the process was reduced to half, which resulted in COD reduction of 30% without any changes in the quality of the products. The grease has made a lot of problem in aerobic lagoons of the so-called industry. And because it has been accumulated on the surface of lagoons which inhibit the transfer of oxygen from air into lagoons which reduced the amount of oxygen required for the aerobic bacteria. A lot of odors, which were an indication of anaerobes bacterial activities, have been smelt all over the factory's area. The grease was then collected in separate small grease collector and removed from the area separately. These results not only to eliminate the previous discussed problem, but also reduced 40% COD and 30% total solids of the wastewater.

In another study, it has been observed that the alkaline wastewater COD concentration was high due to concentrated black liquor which was entered into the wastewater stream from the spillage of the filtrate tank in the CHUKA industry (Akbari, 1994; Neyzehbaz, 1996). The collection of the black liquor into separate tank was managed in the plant. In addition to this collection, another one was the concentration of black liquor from the pump leakage. All were sent into the burning tower after collection. The effect of this action resulted in about

60% reduction in both color and COD of the wastewater. In recent investigation of the Iran Wood Fiber Company, It has been obtained that part of wastewater volume was due to leakage of the pumping of water in the boiler room, and from the cooking room department. Special collection of this clean water into separate stream was then applied in the company, which resulted in 15% reduction the daily wastewater volume.

Another important study in so called industries which are in progress is wastewater reuse in the plant. The wastewater is high in COD and suspended solids. It was the objective of our study to investigate the effect of the wastewater recycles after chemical treatment. In chemical treatment, almost all suspended solids are removed. The effluent from the chemical units is clear from suspended matter but is high in COD. The constituents of the organic material are mainly the same as used in the process. Due to low biodegradability of this wastewater, biological treatments are difficult. Therefore, it is most suitable if the wastewater were reused in the process. The program has been suggested to the company. This program has been applied for several testing to see the effect of it on the quality of the wood fiber.

So far, no adverse effect has been recorded on the wood fiber. This for sure is one of the best waste minimization programs, which resulted in the elimination of wastewater production for slow biological anaerobic/aerobic treatment.

### **Future programs**

There are many research programs, which will be investigated in the future for waste minimization in the Caspian Sea. The important ones are given as follows:

- a) The first plan is to identify the point sources of pollution in the Caspian seaboard. This includes the pollution from all industries, commercial places and cities around the Caspian Sea.
- b) The second task is to identify as much as possible, the nonpoint pollution sources and to characterize them as point sources of pollution.
- c) The third plan is to determine the contribution of each point source pollutant including domestic, industrial, business offices and nonpoint sources in the Caspian Seaboard and to prepare dispersion map of pollutant sources.
- d) The forth task is to investigate the effect of these pollution on the aquatic life of the Caspian Sea.
- e) The last plan is to measure the amount of oil pollution in the Caspian Sea.

### **Conclusion**

Overall, intensive anthropogenic pressures, such as industrial and municipal wastewater discharges and

developments of large- scale hydro schemes have detrimental impacts on natural ecosystems of the Caspian Sea. A sharp decrease in the diversity of the benthic fauna of the Caspian Sea has been reported. In the northern part the diversity has decreased from 78 to 46 species, and in the southern and central part the number of species has decreased by one third. In Baku Bay and off Sumgayit crustaceans and some species of mollusks have drastically declined. Bulk stocks of commercial fish species have significantly reduced in last decades. The sturgeon population has suffered especially. Twenty years ago, about 20 -25,000 tons of sturgeons were harvested in the Caspian Sea annually. Over the last 20 years, the total catch has decreased by 90%.

An accident or oil spill in the Caspian would severely harm an economic resource of the coastal communities and as an inland sea, the Caspian is more vulnerable to oil spills and pollution. There are also many dangers of the Caspian such as its seismicity and extreme variations in water levels that make the chances of accidents more likely. Therefore, command and control techniques, in the guise of technology specifications, are a valid tool in setting environmental policy. An important aspect of these specifications however, is to provide incentives for firms to develop better technologies. This can be done by setting pollution thresholds and allowing firms to devise their own methods for controlling pollution.

At present their quantity has been reduced somewhat with the operation of the Great Baku sewer system and amounts to about 800 million m<sup>3</sup>/yr. The bottom sediments impregnated with petroleum hydrocarbons in Baku Bay amounts to 10 - 12 m. They contain hydrocarbons, phenols, heavy metals, acids, alkalis, and other highly toxic and poisonous substances. According to preliminary calculations, about 200 million tons of toxic substances, the concentrations of which exceed the maximum allowable by hundreds of times, have accumulated in the beds. This is particularly true of the Caspian Sea region is a special case of closely integrated natural, political, environmental, social, and economic issues. It is in the interests of all branches of the economy to learn how to move on along the road of sustainable development, given the very large variations in the Sea level. This will be impossible, however, without effective international cooperation. Broadly speaking, effective management of the Caspian Sea and its resources cannot be achieved without concerted action by all five riparian countries. Only a holistic approach at the international level can make economic development of the region truly sustainable. It also, requires good scientific information and vigilant monitoring of conditions so that if the management strategies are not working they can be adjusted. It is apparent therefore, that future resource and environmental management cannot be accomplished effectively without an integrated and intelligent national effort, rather than a piecemeal and

localized approach.

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