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Assessment of Dissolved Salts Concentration of Seawater in the Vicinity of Karachi

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Abstract. The steady movement salts swept from the earth's crust by multiplicity of sources drained towards sea. Finally the evaporation of seawater to the atmosphere makes the ocean salty. Gaseous and solid discharges from volcanic activity, suspended solids run-off, and dissolving of materials from deposition of sediments on the oceanic floor also contribute the high salt concentration in the seawater. The quantity of total dissolved salts is reduced as a result of precipitation, surface water run-off or melting of ice caps over the sea. This study was conducted to investigate the amount of dissolved salt present in seawater in the vicinity of Karachi. For this purpose six locations were selected around the city; such as, Lyari River, Sand Pits, Karachi Port Trust, Kiyamari, Manhora and PRC Towers. It was found that the amount of total dissolved salt in seawater was more or less similar at five locations except one place at the joining point of Lyari River. The chlorides, sodium, sulfates, potassium, magnesium and conductivity were found 22, 18, 13, 06, 09 and 13 times lower at Lyari among other places. It is concluded that fresh water from Lyari drain reduced the dissolved salt content near the joining point of fresh water with seawater.

Keywords: Seawater, Dissolved salts, Conductivity, Salinity, Fresh water.

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1 Introduction

The rapid pace of urbanization and population explosion is the main cause of environmental degradation in the world. It requires in-depth understanding of the sources, and causes of environmental impacts, and scientific and technical methods to improve the environmental quality [1]. Water is found abundantly in nature, and covers approximately three-quarters of the earth. In spite of its abundance, several reasons limit the water availability for the use of human beings. The first living and breathing creature set flippers on planet earth in the seawater [2], [3]. Scientists believed that the earth was covered by water, soon after its existence [4]. Oceanic water accounts for 97% of total water available on the earth, with large part of ice covered seawater. It is interesting to note that seawater existing in form of ice is not practicable for human needs. Of the remaining 3 percent; 2 percent is tangled in glaciers and ice caps and, along with soil and atmospheric moisture which is also unapproachable. Thus, for in general livelihood and the support of technical, industrial, commercial and agricultural activities, human must depend upon the remaining 0.62 percent found in fresh water lakes, rivers and groundwater supplies. All kinds of water; even precipitation contain dissolved salts and sometimes such salty water did not show salty taste. Since, the oceanic water contains intolerable amounts of dissolved salts & chemicals which is make it unfit for human consumption because it taste is noticeable [5], [6]. The brackish nature of the oceanic water is more understandable, when it is compared with the salt content of bodies of fresh water.

The composition of seawater is exaggerated by the inclusion of dissolved salts. These dissolved salts associated with various forms of water transported and reached to the ocean from the erosion of rocks, volcanic eruptions, rivers, and many other means. The composition of oceanic water varies from one region to other. There are two major variables in seawater such as, salinity and temperature (the dissolved salts concentration). These variables work in combination to control the density of the seawater. Subsequently, the density is a most important aspect which controls the vertical flow via condensation of the seawaters, and the salinity is the major factor in the deliberation of human use. The average salinity of seawater is 35 parts per thousand by weight. The main dissolved salts in seawater include sodium and chloride that constitutes 85% of dissolved salts which are responsible for its brackish taste. Since the salt ion is heavier than water molecules, seawater is denser than fresh water. The main constituents of river water are hydrogen carbonate and calcium. Rain water contains 7.1 mg/l of total dissolved salts (TDS), whereas the river water and seawater contains 118.2 and 34,400 mg/l of TDS respectively. It is well known fact from the studies that the river water contained 15 times more concentration of TDS than rain water and the TDS of seawater is 300 times higher than that of river water. It is interesting thing about the dissolved salt, that it is always made up of same types of salts with same proportion to each other, even if the salinity may be different than average [7]. The concentration of chlorides, sodium, sulfate, magnesium, potassium in average seawater is 19.3 10.7, 2.7, 1.3 and 0.4 parts per thousand respectively [8].

The density of an object is the ratio of its mass to its volume. The unit of water density in S.I system is 1000 kg/m^3. Density may as well be articulated in terms of specific gravity, as ratio of the density of a substance to the water density. The water density is having direct relationship with the salinity and inversely proportionality to the temperature. Although, the specific gravity of sea water varies from place to place ranges from 1.020 to 1.030, while the specific gravity of fresh water is about 1.000. Deviations in salinity also cause the freezing point of seawater to become little bit lower than freshwater. Fresh water freezes at 0°C. As the salt ions interplays with the hydrogen bond formation; therefore the seawater does not have a fixed freezing point although it mostly freezes at -1.94 °C. Surging salinity also results in increased level of the seawater density [9], [10]. The flow of superficial waters of the ocean is driven by winds, whereas, the flow of deep waters is driven by difference in density. The profoundly deep ocean is having light water layer on top and densest water at the bottom. Water inclines to travel horizontally all the way through Deep Ocean, moving along with the lines of equivalent density. Vertical flow of seawater is very problematic, as it not easy for water to move transversely through constant density lines and then along them.

pH is one of the steady measurements in marine water. It is a measure of the alkaline or acidic nature of any substance. Seawater has an exceptional buffering system with the intermingling of carbon dioxide (CO_2) and water, so that it usually always having pH range of 7.5 to 8.5. Neutral water is having pH level of 7. While alkaline substances are having pH range of 7-14 and acidic substances have pH range of 7-1. High levels of acidity or alkalinity both, results in killing of marine life but the oceans are very much stable in pH levels. If oceanic water seems to be out of standard or normal range than something would be tremendously wrong. The pH and salinity of seawater are comparatively stable measurements; however, nutrients, temperature and dissolved oxygen may vary. Electrical conductivity (EC) provides the approximation of total quantity of dissolved ions in water or total dissolved salts (TDS). The changes in the composition of seawater, in both oceanic and estuarine waters, result in variations of the conductance–density relationship [11]. Conductivity of seawater has strong dependence on temperature, somehow less strong dependence on salinity, and very feebly on pressure. Salinity as calculated through conductivity seems to have more close association to the actual dissolved components than chlorinity and is sovereign of salt composition. The unit of electrical conductivity is micro Siemens per centimeter (μS/cm).

Chlorides are a saline compounds resulted from chemical reaction of metals and gas chlorine. Few common compounds of chlorides include magnesium chloride ($MgCl_2$) and sodium chloride (NaCl). Aquatic organisms especially fishes find it difficult to survive in increased concentrations of chlorides [12]. Sulfates are most important anion in the reservoirs of hard water and are regarded as second to bicarbonates. Sulfates may result naturally or may be formed from manmade activities. They are present in marine water as a result of breakdown plants and their leaves that passed through the soil or rocks comprising of gypsum and other common minerals of which may include in atmospheric deposition. Sulfate is a common form

of oxygenated sulfur. Problems triggered by sulfates include its capability to form strong acids which in result may change the pH level [13], [14].

Sodium stems from soils and rock. For billions of years sodium is washed out from soils and rocks ending up in ocean, where it may remain about 50 million years. Seawater contains about 11000 ppm sodium, whereas river contains only 9 ppm [15]. It strongly reacts with water and forms sodium hydroxide (caustic soda) and hydrogen gas. Potassium occurs in various minerals, from which it may be dissolved through weathering processes. Some clay minerals also contain potassium. It ends up in oceanic water through natural processes, where it mainly settles in sediments [16]. Seawater contains about 400 ppm potassium while river water generally contains about 2-3 ppm. It is not a water soluble element, but is reacts with water and forms potassium hydroxide and hydrogen gas. Magnesium is the most commonly found cations in oceans after sodium. Magnesium is liable for oceanic water hardness besides other alkali earth-metals. It is basically having low reactivity, but its reactivity surges with increase in level of oxygen. It is having tendency to reacts with water and formulates hydrogen gas and magnesium hydroxide. Magnesium may be obtained from many minerals like, dolomite or calcium magnesium carbonate [$CaMg(CO_3)_2$] and magnesite or magnesium carbonate ($MgCO_3$). It may erode out from rocks and its concentration increases in marine water.

2 Materials and Methods

The sea water samples were the main experimental materials. For this purpose, six locations near Karachi were selected namely; Lyari River, Sand Pits, Karachi Port Trust, Kiyamari, Manhora and PRC Towers for the appraisal of dissolved salt concentration. The samples were collected by using 2 liter hard plastic screw-capped bottles. The bottles were sterilized to avoid contamination of physical, chemical and microbial means. Each bottle was properly tagged and labeled. The date, hour and exact location were marked on the tag. Three samples were taken from each location for average results repeatedly for seven months, from April, 2008 to October, 2008. The samples were stored at low temperatures of about 4°C. Afterwards, these samples were brought to the laboratory, and their analysis was made according to the international standard procedures and methods [9]. The sensitive parameter pH of seawater was measured immediately on the spot. The alkalinity was examined volumetrically by titration with N/50 $H2SO_4$ and the chlorides content were tested by turbidimetric method. Electrical conductivity meter was utilized for the determining conductivity of seawater while magnesium was analyzed by EDTA titrimetric method. In addition sodium and potassium were investigated by using flame photometer.

3 Results and Discussion

The average concentration of chlorides, sulfates, sodium, magnesium, potassium and electrical conductivity of five places; namely Sand Pits, Manhora, Kiyamari, KPT and PRC Towers were found 19556, 2905, 9712, 1512, 360 and 50846 ppm respectively as shown in Table.1 and graphically represented in Fig.1-4. In contrary at Lyari River joining point the concentrations of the above parameters were 880, 218, 549, 164, 63, and 4053 ppm.

Table 1 Average results of salt concentration of seawater in the vicinity of Karachi

Sampling Location	pH	Electrical Conductivity (µS/cm)	Chlorides (ppm)	Sulfates (ppm)	Sodium (ppm)	Potassium (ppm)	Magnesium (ppm)	Alkalinity (ppm)	Specific Gravity
Lyari	7.7	4,053	880	218	549	63	164	355	1.022
Sand Pits	7.4	50,529	18,921	2,885	2,900	366	1,510	186	1.022
Manhora	7.4	51,357	19,740	2,949	10,100	379	1,534	173	1.023
Kiyamari	7.4	51,314	19,650	2,926	9,557	364	1,536	163	1.023
KPT	7.5	49,743	19,669	2,830	9,814	362	1,511	151	1.022
PRC Tower	7.4	51,286	19,800	2,933	9,291	327	1,471	150	1.023

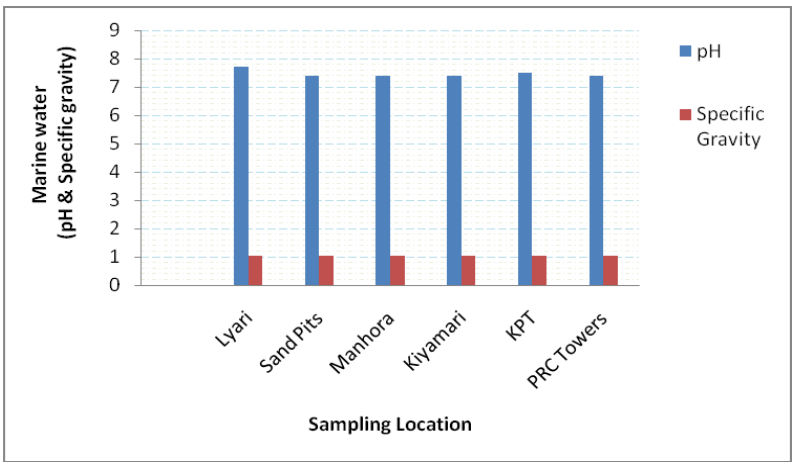

Fig. 1. pH and Specific gravity of seawater samples

The average specific gravity of seawater was found 1.022 in the samples taken from the Lyari, while, in other places it was 1.023. The concentration of analyzed samples from Lyari sampling point showed 22, 13, 18, 09, 06, and 13 times lower values of chlorides, sulfates, sodium, magnesium, potassium and electrical conductivity as compared to other five locations. Since, the pH and alkalinity values were found more than other places.

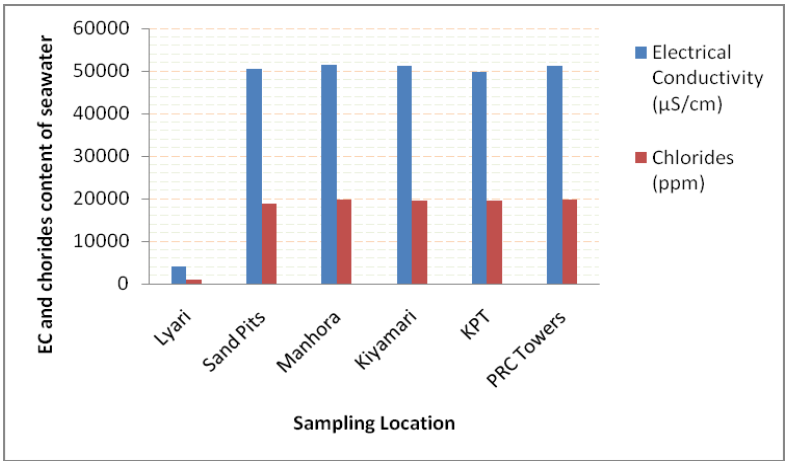

Fig. 2. Electrical conductivity and Chlorides of seawater samples

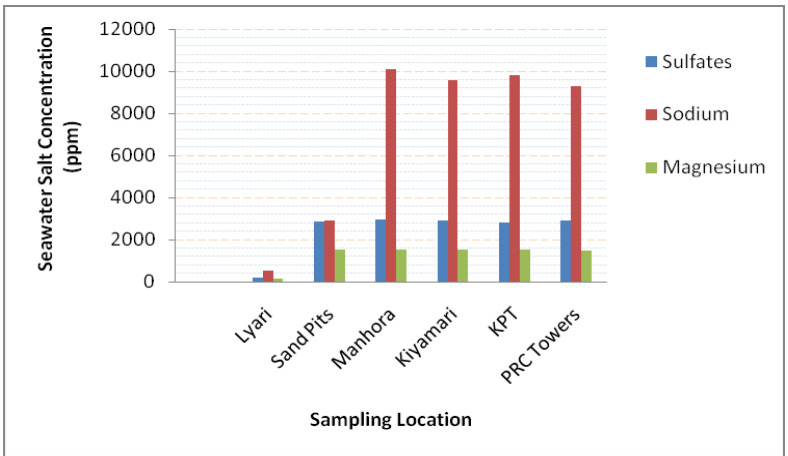

Fig. 3. Sulfates, Sodium and Magnisium concentration of seawater

The pH of sea water at Lyari was found 7.7 and other places 7.4. The level of high salts was observed in the sea in all samples except the samples which were taken from Lyari observation point. It is due to less addition of fresh water or from surface run-off from rain water to the sea. The samples analyzed from Lyari, established significant difference in the concentration of salts among other locations. The results of examined samples displayed same behavior of salt concentration in most places except Layari river mixing point. The analyzed samples of seawater demonstrated extremely high dissolved salts as per their trend in overall oceanic waters of the world except in the entrance of freshwater bodies.

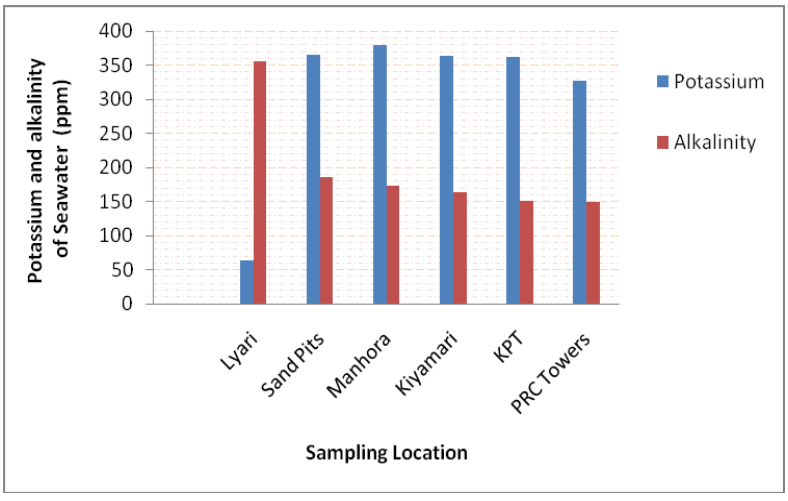

Fig. 4. Potassium and Alkalinity of seawater samples

4 Conclusion

The experimental result revealed that the dissolved salt concentrations at all places were found more or less similar except one location at Lyari River mixing point. The samples taken from Lyari displayed 22, 13, 18, 09, 06 and13 times lower values than other five locations of chlorides, sulfates, sodium, magnesium, potassium and electrical conductivity respectively. It is concluded that the freshwater drains from Lyari River reduced the dissolved salt content of seawater near its joining point.

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