SEASONAL CHANGES IN THE SALINITY OF THE ZAYANDEHRUD RIVER

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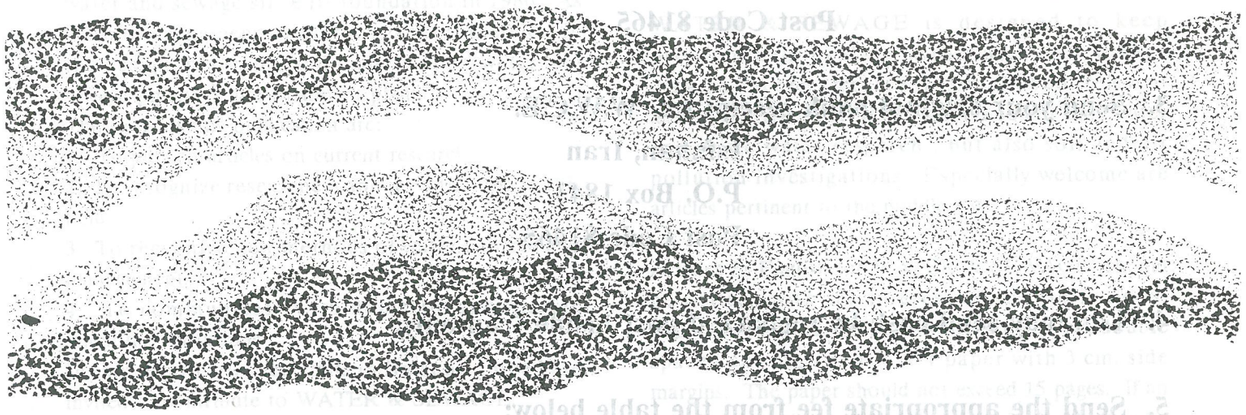


The Zayandehrud River is the major artery of the Isfahan plain and it's water quality is of prime importance to municipal, agricultural and industrial development in the area. Salinity of the water in this river and its seasonal changes along the river's course was determined by analysis of samples taken from 14 stations along the river's course during a 3 year period. Electrical conductivity and concentrations of calcium, magnesium, sodium, potassium, chloride, sulphate and bicarbonate ions were determined.

Results indicated a gradual increase in electrical conductivity and concentration of calcium, magnesium ,sodium, potassium, chloride, sulphate and bicarbonate from stations 1 to 10. Then a much higher increase was seen from stations 10 to 13. Electrical conductivity and concentrations of the above mentioned ions slightly decreased from stations 13 to 14. Seasonal changes of electrical conductivity were minor from stations 1 to 8. The highest electrical conductivity was recorded in winter.

From station 8, however, seasonal changes of electrical conductivity were recorded in summer. Seasonal changes of various cations and anions concentrations were also determined. Seasonal changes were not the same for different ions and generally were slight up to station 10 and increased dramatically from stations 10 to 14.

INTRODUCTION

Life in Isfahan depends on the Zayandehrud River. Protecting the water quality for potable water, agricultural, industrial and wildlife use is extremely important. Pollution of surface water with various kinds of contaminates, either inorganic or organic, and increasing water salinity pose real dangers for the human environment and agriculture in this province.

The main source of pollution for the Zayandehrud River is cations, anions, nitrogen, phosphorus and heavy metals existing in irrigation runoff. This phenomena causes the river to become saline and contaminated. The environment around and downstream from the river is in danger. If serious measures are not taken soon, the well being of humans and other creatures will be threatened.

The first step in protecting the environment of the Zayandehrud River is gathering continuous data regarding the quality fluctuations at various times and places and finding the contaminating sources. Analysis of the Zayandehrud River in the past usually was not consistant. At any rate, the results of these analysis show an increasing amount of salt, sodium chloride and sulphates in the water; electrical conductivity is also rising.

METHODS & MATERIALS

This study took place over three years, summer 1367 to fall 1370 (1988 - 91). Samples were taken from fourteen stations along the Zayandehrud River:

1. Murgan Bridge
2. Kalleh Bridge
3. Zarreenshahr Bridge
4. Sadehneeku Abad
5. Baba Mahmood Bridge
6. Garmaseh
7. Vaheed Bridge
8. Bazorgmehr Bridge
9. Choom Bridge
10. Zeyyar Bridge
11. Shah Karam
12. Ajeeyeh Bridge
13. Varzeeneh Bridge
14. Gavkhuni Marsh

The first station is 70 km. southwest of Isfahan and station #14 is 145 km. east of Isfahan. Sampling occured over 3 days. Two liters of water were taken in polyethaline bottles at each station (fig. 1).

Labratory analysis showed the main cations to include sodium, calcium, magnesium and potassium; the main anions included: chloride, sulphates and bicarbonates. Computer calculations were made for the amounts of seasonal fluctuation in electrical conductivity and concentrations for these three years at each station (figs. 2 - 9). Cationic and anionic concentrations are shown by mmole per liter and electrical conductivity by microsiemens per centimeter.

RESULTS & DISCUSSION

The seasonal fluctuation of electrical conductivity (salinity) in Zayandehrud River water along the river from the first to the fourteenth station is shown in

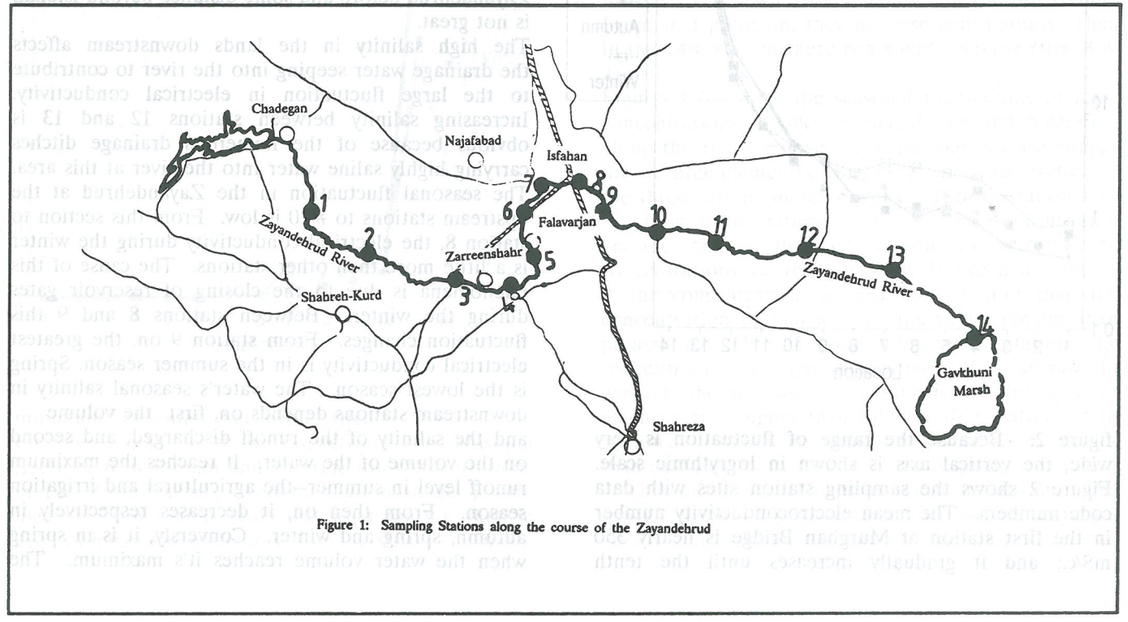


Figure 1: Sampling Stations along the course of the Zayandehrud

Figure 2: Seasonal Fluctuation of Electrical Conductivity in the Zayandehrud

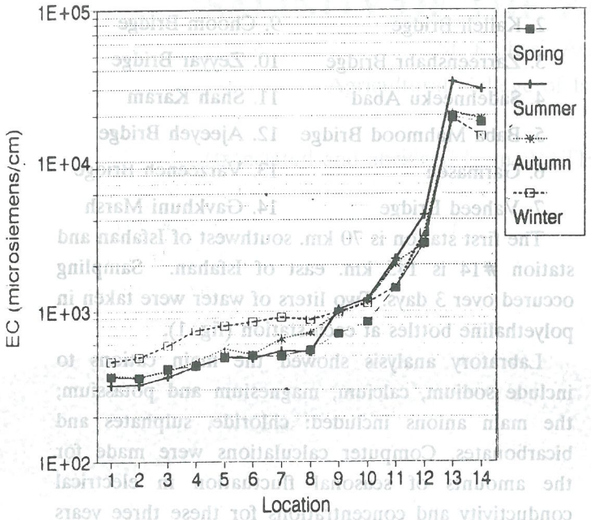


Figure 4: Seasonal Fluctuation of Chloride Ions in the Zayandehrud

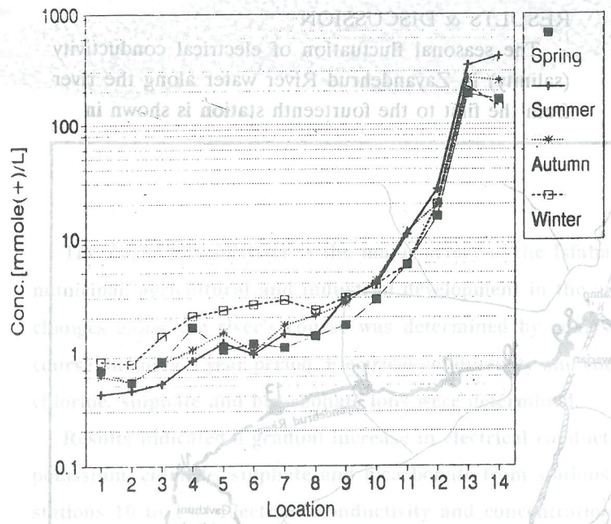
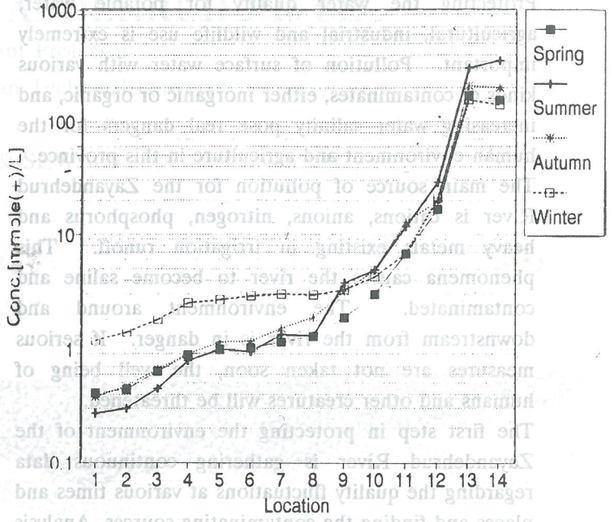


figure 2. Because the range of fluctuation is very wide, the vertical axis is shown in logrythmic scale. Figure 2 shows the sampling station sites with data code numbers. The mean electroconductivity number in the first station at Murghan Bridge is nearly 350 mS/c.; and it gradually increases until the tenth

Figure 3: Seasonal Fluctuation of Sodium Ions in the Zayandehrud



station at Zeyyar Bridge to 1000 mS/cm. After station 13 the electrical conductivity of the Zayandehrud River water slightly decreases. The cause of increasing electrical conductivity in the river is mainly due to agricultural runoff entering the river, because the land upstream of Isfahan in generally not saline. Therefore increasing salinity in the Zayendehrud before and some distance beyond Isfahan is not great.

The high salinity in the lands downstream affects the drainage water seeping into the river to contribute to the large fluctuation in electrical conductivity. Increasing salinity between stations 12 and 13 is obvious because of the numerous drainage ditches carrying highly saline water into the river at this area. The seasonal fluctuation in the Zayandehrud at the upstream stations to #10 is low. From this section to station 8, the electrical conductivity during the winter is a little more than other stations. The cause of this phenomena is due to the closing of reservoir gates during the winter. Between stations 8 and 9 this fluctuation changes. From station 9 on, the greatest electrical conductivity is in the summer season. Spring is the lowest season. The water's seasonal salinity in downstream stations depends on, first the volume and the salinity of the runoff discharged, and second on the volume of the water. It reaches the maximum runoff level in summer--the agricultural and irrigation season. From then on, it decreases respectively in autumn, spring and winter. Conversly, it is in spring when the water volume reaches it's maximum. The

Figure 5: Seasonal Fluctuation of Calcium Ions in the Zayandehrud

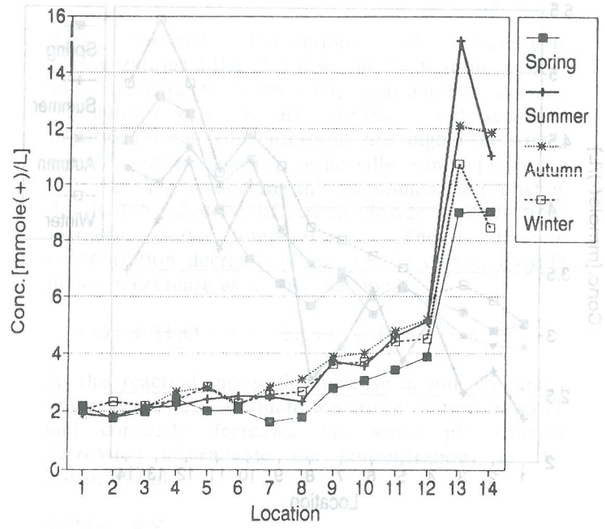
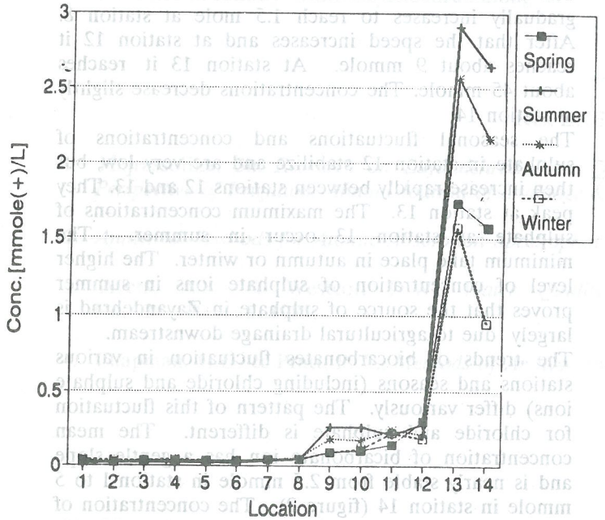


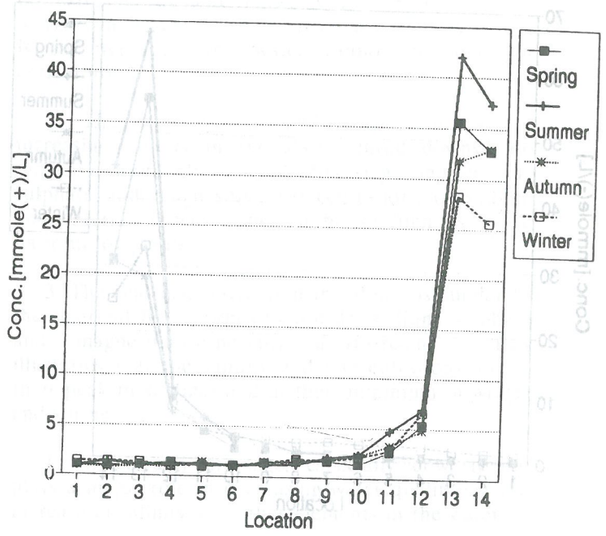
Figure 7: Seasonal Fluctuation of Potassium Ions in the Zayandehrud



minimum is autumn and winter (fig.2).

Figures 3 and 4 show respectively the seasonal fluctuation in sodium and chloride ion concentrations in the Zayandehrud. The fluctuation range is very high. The logrythmic scale was used for the verticle axis. Comparison of figures 3 and 4 shows the mean

Figure 6: Seasonal Fluctuation of Magnesium Ions in the Zayandehrud



concentration of sodium and chloride ions and their seasonal flux along the river have a similar pattern. At the same time, there is some similarity with the pattern of electrical conductivity concentrations in the Zayandehrud. This similarity is especially high downstream, and it is apparent the salts discharged in the runoff are mainly sodium chloride. The concentrations of sodium and chloride are about .5 mmoles in the first station and gradually increase to reach nearly 2 mmoles in the 8th station. From that point on, they increase continuously. Then in the 14th station there is a slight decrease (figs. 3 & 4).

Figures 5,6,7 show the seasonal fluctuations of ionic concentrations of calcium, magnesium and potassium along the rivers course. The fluctuations are similar for all three elements. Generally, the concentration of the three cations increase was small from station 1 to 8 ; then from stations 8 to 13 the concentration became high. Between station 13 and 14 the concentrations decreased slightly. Between stations 1 - 9, the concentration of calcium is greater than the concentration of magnesium, and much greater than potassium. But beyond the tenth station the concentration of magnesium is more than calcium. In general, the increase in the mean concentration of magnesium is higher than calcium after station 8. In stations 11 and 12 its concentration becomes greater than calcium. As in station 13, its mean concentration reaches nearly three times as much as calcium. The concentration of potassium in this course increases greatly, but its mean concentration reaches 1/10 of the

Figure 8: Seasonal Fluctuation of Sulphate Ions in the Zayandehrud

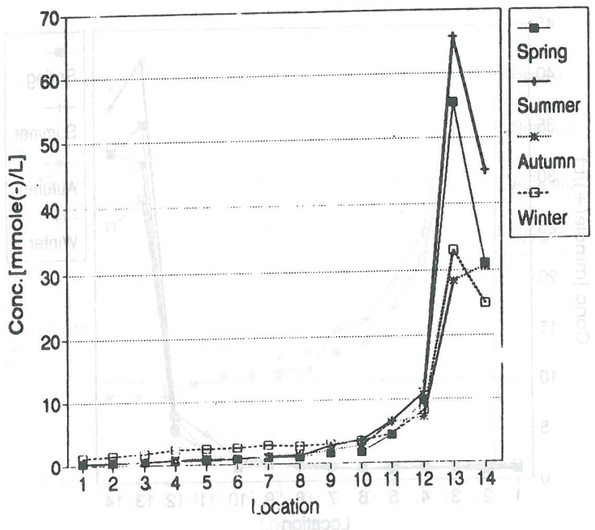
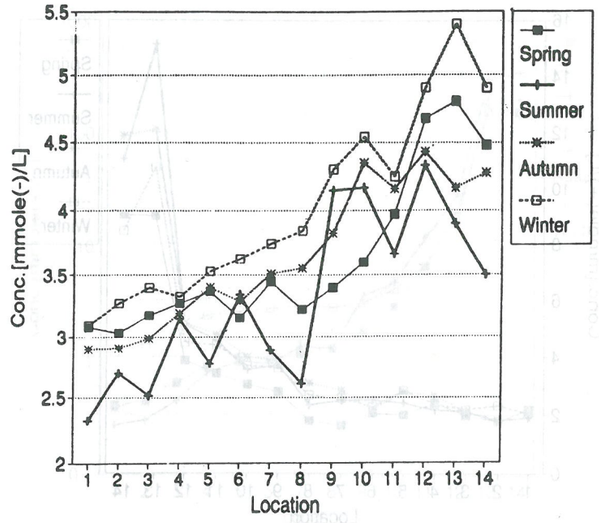


Figure 9: Seasonal Fluctuation of Bicarbonate Ions in the Zayandehrud



calcium concentration at station 13. The increase of concentration of alkaline elements and soil alkalinity included calcium, magnesium and potassium. Primarily this was due to agricultural water drainage--then from industrial and domestic waste water.

The solubility and the mobility of most salts of sodium and magnesium compared to calcium caused the calcium prior to station 10 to be at its maximum level; after this station it increased at a slower rate. From station 12 it was less than the sodium and magnesium concentrations. This is because a part of calcium ion percipitates as calcium carbonate due to decreasing carbon dioxide pressure.

$Ca_2 + 2HCo_3$ ----------$CaCO_3 + CO_3 + H_2O$

The reason why CO2 pressure decreases is probably due to the decreasing biological activities or B.O.D. (biochemical oxygen demand), which results mainly from organic and inorganic pollution sources.

The seasonal fluctuations of calcium concentrations before station 12 is low, and for magnesium and potassium even less so. After station 12, the seasonal fluctuations increases greatly. At station 13 it reaches its peek for all three elements. Between stations 12 and 14 the greatest concentration for all three elements occurs in summer. The lowest concentration is in spring or winter. Accordingly, this similarity shows the 3 elements entering the river off of agricultural drainage increases in the summer and decreases in the winter depending on the volume of agricultural drainage entering the river.

Figure 8 shows the seasonal fluctuation of sulphate concentrations along Zayandehrud's course. The time and course fluctuations are quite similar to the calcium and magnesium concentration fluctuations. The mean concentration is about 0.5 mmole and gradually increases to reach 1.5 mole at station 8. After that the speed increases and at station 12 it reaches about 9 mmole. At station 13 it reaches about 45 mmole. The concentrations decrease slightly at station 14.

The seasonal fluctuations and concentrations of sulphate in station 12 stabilize and are very low, but then increase rapidly between stations 12 and 13. They peak at station 13. The maximum concentrations of sulphate at station 13 occur in summer. The minimum take place in autumn or winter. The higher level of concentration of sulphate ions in summer proves that the source of sulphate in Zayandehrud is largely due to agricultural drainage downstream.

The trends of biocarbonates fluctuation in various stations and seasons (including chloride and sulphate ions) differ variously. The pattern of this fluctuation for chloride and sulphate is different. The mean concentration of bicarbonate ion has a gentle slope and is nearly stable from 2.5 mmole in station 1 to 5 mmole in station 14 (figure 9). The concentration of bicarbonate ions until station 11 is more than chloride and sulphate. But from stations 11 on, it decreases and its amount is clearly lower than sulphate and chloride (figs. 4 & 9).

A slight increase in bicarbonate concentration occurs because of the low solubility of bicarbonate salts and the low amount of this salt in agricultural drainage water. Secondly, as was discussed about the calcium ion, its slight increase was from percipitation of bicarbonates. This in turn is caused by calcium concentration increase and carbon dioxide pressure decrease.

The seasonal fluctuations of bicarbonate concentrations differ also from the fluctuation of other ions. Figure 9 shows first, considerable seasonal fluctuations exist in all stations , and secondly, bicarbonate ion concentrations are higher in winter than in other seasons (especially summer) at all stations. The reason for this phenomena is probably due to the reduction of carbon dioxide pressure from increasing water temperatures. The bicarbonate concentration decrease is due to the carbon dioxide pressure decrease as in this reaction:

$$CO_2 + H_2O \text{ --------- } HCO_3 + H^+$$

As this reaction shows, the increase in soil pH causes the increase of bicarbonate ion concentration in water and conversly decreases the water pH causing decreasing bicarbonate ion concentrations in the Zayandehrud.

SUMMARY

We can summarize the following from the study of salinity in the Zayandehrud River:

1. Increases in salinity in the Zayandehrud along its course are extremely high, and at the same time, non-liniar. Most of this increase occurs in the downstream segment between Zeyyar Bridge and Varzeeneh Bridge. The salinity after Ajeeyeh Bridge is so high that the water cannot be used for agriculture.

2. The main cations and anions causing the increasing salinity in the Zayandehrud downstream include sodium chloride at the first stage, and secondly sulphate and magnesium. Concentrations of sodium and chloride downstream can be so high as to be harmful for plants.

3. The seasonal fluctuation in salinity is similar to the seasonal fluctuation of chloride, sodium, sulphate and magnesium--especially downstream. This illustrates that the salinity and concentrations are at their peak in summer and at their minimum in winter and spring.

4. Agricultural drainage, especially downstream, plays a major role in decreasing water quality via the increase in salinity and other elements in the water.

5. Because quality analysis of the Zayandehrud River is so important, the study should be expanded to include nitrogen, phosphorus and other heavy metals.

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