628.1.032

ÖZ NURTAÇ, Assoc.Prof.
ÇELEBİ AHMET, Ph.D.
Sakarya University Faculty of Engineering, Department of Environmental Engineering, 54187, Sakarya, Turkey
HALIL İBRAHIM UZUN
Yıldız Technical University Environmental Engineering Department Davutpaşa Campus 34220 Istanbul, Turkey

ASSESSMENT OF AN IMPORTANT RIVER WATER QUALITY IN TURKEY

Представлено якісні характеристики вод поверхневого джерела (р.Ріва, Туреччина) за 13 параметрами. Встановлено відповідність якості цих вод III та IV категоріям згідно з нормативами Закону Турецької Республіки "Про боротьбу із забрудненням водних ресурсів". На основі проведеного кореляційного аналізу динаміки якості води за сезонами року визначено найбільш небезпечні (забруднені) пункти відбору проб.

Ключові слова: річка Ріва (Туреччина), якість води, статистичний аналіз, динаміка показників.

Представлены качественные характеристики вод поверхностного источника (р.Рива, Турция) по 13 параметрам. Установлено соответствие качества этих вод III и IV категориям согласно нормативам Закона Турецкой Республики "О борьбе с загрязнением водных ресурсов". На основе проведенного корреляционного анализа динамики качества воды по сезонам года определены наиболее опасные (загрязненные) пункты отбора проб.

Ключові слова: река Рива (Турция), качество воды, статистический анализ, динамика показателей.

In this study, 33 water samples were taken from 4 different points of Riva River (Turkey) with the total number of 132 samples. 13 parameters which included pH, Temperature (T), Dissolved Oxygen (DO), Electrical Conductivity (EC), Salinity (S), Total Suspended Solids (TSS), Total Volatile Suspended Solids (TVSS), Total Phosphorus (TP), Nitrate nitrogen (NO_3-N), Ammonium nitrogen (NH_4-N) and Total Kjeldahl Nitrogen (TKN) were measured. It is found that the water had III. and IV. quality according to Turkish Water Pollution Control Act. Correlation Analysis, Temporal and Spatial Description Analysis, Analysis of Variance (ANOVA), Temporal and Spatial Homogenous Group Analysis were conducted. The average values of 12 parameters except Total Kjeldahl Nitrogen (pH, T, DO, EC, S, TSS, TVSS, BOD, COD, TP, NO_3-N, NH_4-N) depending on

season of the year. Only 4 parameters (EC, S, BOD and COD) depend on the sampling points. It is revealed that the most polluted points were the 3. and 4. Sampling points due to the pollutants.

Key words: Riva River, water quality, statistical analysis.

Introduction

Water pollution and its effects are observed in our country just as many other region of the world, particularly in Marmara Region where there is intense industrial activities. Within the Marmara Basin, the industrial activities that stand out the most are food production and metal industry. Because these activities are intense in Marmara Basin, the burden on the water resources is in large amounts. The intensity of the pollution-causing activities and the insufficiency of the water resources to supply the demand require a specific management over the basin [1].

The aim of this study is to determine the water quality (physical and chemical properties) of Riva River, which is located in the city of Istanbul (Cekmeköy and Beykoz districts) and to investigate the links between the parameters and their changes with time and sampling points statistically.

Material and method

Study area Riva River, which also hosts Omerli Dam, has the largest basin reaching the Black Sea that is closest to Istanbul on the Anatolian side with its drainage area of 895 km^2[2]. Riva Basin is approximately 70 km long through South-North direction on the Anatolian side in Istanbul. Omerli Dam, which supplies the 48% of Istanbul's drinking water, is settled on the upper basin and collects water from a 34 km part of the Riva River [3]. The rest of the river from Omerli Dam to the Black Sea, which is a part approximately 35 km longitude, is used for wastewater discharge. For this study, water sampling was performed from 4 different spots of 35 km long Riva River.

Pasaköy Advanced Biological Wastewater Treatment Plant, which collects and treats the wastewaters of Umraniye, Sancaktepe, Sultanbeyli and their periphery. When deciding on the first sampling point, the intersection point of the leakage waters from the periphery, secondary rivers and the discharged water from the treatment plant was taken into consideration. The second sampling point is surrounded by agricultural fields and special hobby gardens. Furthermore, there were also a dog farm, paper factory and plastics factory in the region. Thus, it was considered that chemical wastes might spread into the the river because of these fields, gardens and factories. The third sampling point was surrounded by luxurious settlements. Most of the wastewater of the buildings around was connecting to the river directly. There are groves and sedgy around the spot, which is why there are many areas close by to have picnics or other leisure activities. The fourth sampling point is located after a factory that manufactures detergents and chemical products. There are also many restaurants and picnic places around that spot. The Riva River System Drainage Basin and sample points are shown in Figure 1.

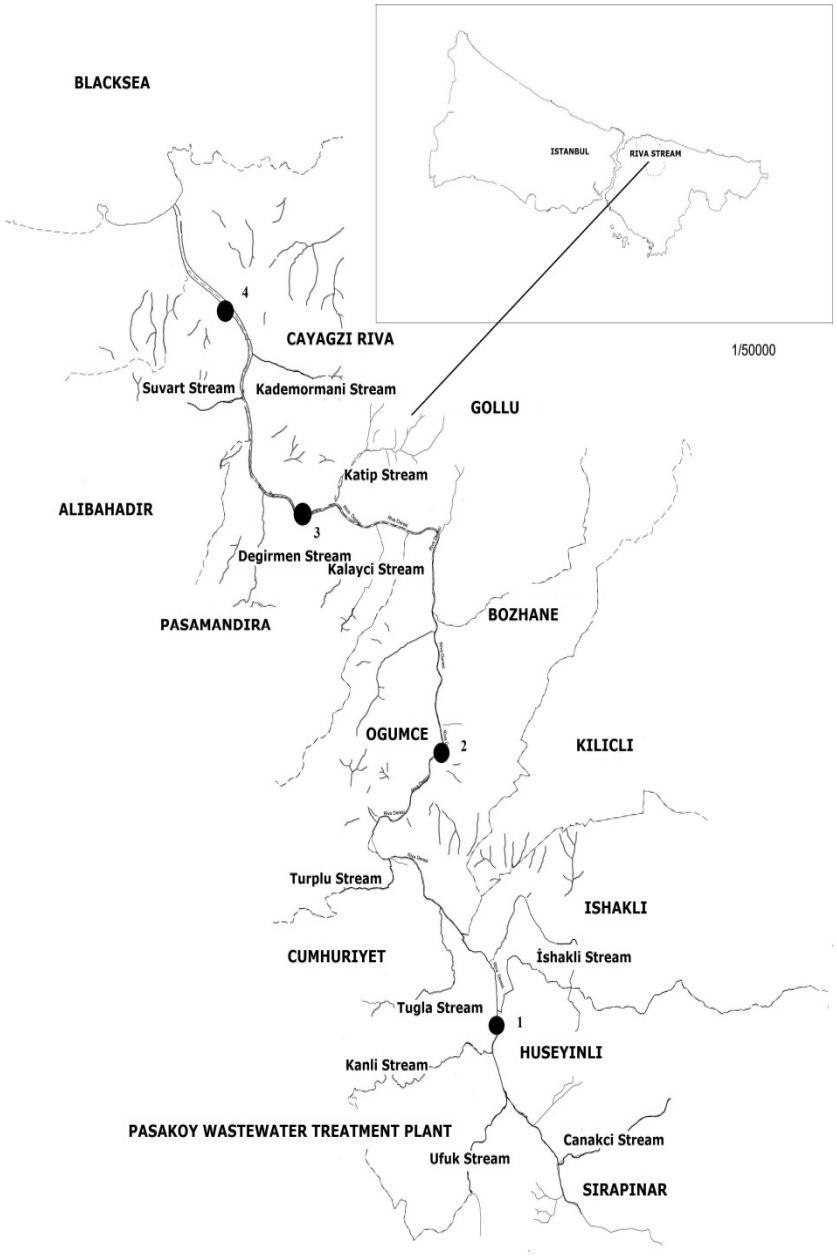

Fig. 1. Sampling stations of the Riva River

A total of 13 parameters, pH, Temperature (T), Dissolved Oxygen (DO), Electrical Conductivity (EC), Salinity (S), Total Suspended Solids (TSS), Total Volatile Suspended solids (TVSS) [4], Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total phosphorus (TP), Nitrate nitrogen (NO_3-N), Ammonium nitrogen (NH_4-N) and Total Kjeldahl Nitrogen (TKN) in 4 sampling stations were measured over a period of eighteen months. Standard analytical methods were used to determine all these parameters [5].

The existing water flow of the river starts with the discharged water from

The statistical analysis and graphs of the water quality parameters investigated in this study were prepared on Microsoft Office Plus Excel 2010 software, which is a part of Microsoft Office Professional Plus 2010 series. The interpretive statistical analysis is done by statistical program SPSS on Windows

software. The descriptive analysis, correlation analysis, ANOVA and analysis of homogenous groups were also done. The water quality of the sampling points were determined due to the Turkish Water Pollution Control Act.

Results and discussion

Due to the findings of the measurements and the analysis of the water samples taken from the area, the highest and the lowest values in Riva River are; pH, 7.08 – 7.68; Temperature (T), 8.51 – 26.26 ^{0}C; for DO, 2.16 – 5.77 mg/l; for EC, 537.375 – 2164.75 µmhos×10/cm; for S, 0.033 – 0.96 ppt; for TSS, 18 – 76.87 mg/l; for TVSS, 10.25 – 45.62 mg/l; for BOD, 6.37 – 18.87 mg/l; for COD, 39.26 – 90.62 mg/l; for TP, 1.97 – 5.27 mg/l; for NO_3-N, 1.91 – 4.67 mg/l; for TKN, 4.33 – 7.52 mg/l; for NH_4-N, 0.41 – 4.88 mg/l.

The minimum and maximum averages of the results; for pH, 7.28 – 7.41; for Temperature, 17.64 – 17.97 ^{0}C; for DO, 3.59– 4.77 mg/l; for EC, 848.94 – 1504.3 µmhos×10/cm; for S, 0.32 – 0.82 ppt; for TSS, 35.33 – 38.81mg/l; for TVSS, 19.96 – 23.24 mg/l; for BOD, 10.37 – 14.36 mg/l; for COD, 57.45 – 76.45 mg/l; for TP, 2.86 – 3.34 mg/l; for NO_3-N, 2.83 – 3.18 mg/l; for TKN, 6.02 – 6.44 mg/l; for NH_4-N, 2.19 – 3.18 mg/l.

The water of Riva River is slightly-alkali. pH values are in I. quality [6]. The temporal analysis of homogenous group shows 2 different groups formed. The pH values of 5, 6, 7, 8 and 9. Months, when the temperature is higher, are in 2. group with higher values. It is observed that summer pH values have lower than the winter values, because the water plants consume CO_2 for photosynthesis in larger amounts in hotter days, increasing pH, and pH decreases during winter because of the rainwater.

The water is I. quality in terms of temperature values. 6 different groups were formed due to the results of the temporal analysis of homogenous group. (1. Group represents the months with the lowest average values, whereas 6. Group represents the ones with the highest.) Reaching its average highest temperature value in 9. month and the 10. month being under the 5. Homogenous group proves that the water heats and cools down later than the weather. The water is III. and IV. quality due to DO values. When examined due to the months in the year, the level of DO decreases especially in the summertime, whereas it has higher values during the wintertime.

The EC value, which does not show any changes depending on the sampling points, decreases in the wintertime. The results of the temporal analysis of homogenous groups for EC are gathered under 3 different groups. The lowest group includes 1, 2, 3, and 4. months. This might be explained by a decrease in the amount of dissolved substances. 5, 6, and 7. months take place in the high group, because of the increase in the temperature. However, the taking place of 10. month in particular in the highest group might be because of the conveyance of substance by the surface waters of the precipitations after an arid season, which causes an increase in the amount of dissolved substances.

The results of the temporal analysis of homogenous group analysis are collected into 3 groups. The 11, 12, 1, 2, and 3. months, when the temperature is relatively lower, and when the precipitations lower the salt concentration,

constitute the 1. group. The 6, 7, 8, 9. months constitute the 2. group with higher salinity values, higher values probably caused by the increase in the temperature and therefore the increase in the dissolution of solid substance, and also by the decrease in the flow rate due to evaporation.

The temporal homogenous group analysis done for TSS and TVSS results in 5 different groups. The TSS and TVSS values of the first 7 months can be put together in a group, whereas the other 5 months constitute 4 more groups due to the sudden increase and decreases of the values. It is estimated that this relates to the flow rate of the river. The decrease in the flow rate might have increased the TSS and TVSS values. When the precipitation is less, the values might have decreased as well.

In terms of BOD, water is II. and III. quality. It is observed that the BOD values generally increase with the increase in precipitation, and temperature, and they decrease in the cold season. The homogenous group analysis of the temporal averages of BOD results in 4 different groups. Two parameters that are worth attention in 11, 12, 1, 2, and 3. months are the low temperatures and high precipitations. Because the flow rate decreases, the concentration of the pollutants also decreases, and therefore BOD averages decrease. BOD values are higher when the precipitations are high but the surface of the lands is contaminated during an arid season as it is in 9 and 10. month. It can be said that the water pollution increases due to a decreasing in the flow rate in 4, 5, 6, 7, and 8. months. The spatial analysis of BOD results in 2 groups. Spatial evaluation of BOD denotes that it has the highest value at the 1. sampling point. It can be said that this results from its location, being after the discharges of Pasaköy Advanced Biological Treatment Plant.

Riva River is III. and IV. quality due to COD. It is observed that the COD values generally increase during the rainy season, during the hotter seasons, and decrease during the cold seasons. When evaluated spatially, COD value increases, unlike BOD value. The homogenous group analysis of temporal average values of COD is grouped into 4. The group of the lowest COD values includes 12, 1, 2, 3, and 4. months. This might have resulted from the increase in the precipitations as it is for BOD. 4, 5 and 6. months belong to the 2. Homogenous Group. The reason of this increase in COD in these months might be the decrease in the flow rate or the mixing in of the animal-based fertilizers used for the agricultural fields and gardens to the river. However, the dramatic increase in 8, 9, 10, and 11. months result from the surface water flows that contain high amounts of organic substance to the river, and the increase of agricultural irrigation especially in the 8. month, or the decrease of the flow rates.

The homogenous group analysis of the spatial average values generates 2 different groups. In the river, COD value gradually increases from 1. point to the 3. point, whereas a relatively huge increase happens at the 4. point. Because COD is parameter including BOD, BOD is expected to increase as well. However, the measurements show an inverse ratio involved. The reason of this inverse ratio might be the industrial material mixing into the water from the industrial facilities between 2. – 3. sampling points and especially 3. – 4. sampling points. The

wastewaters of the detergent factory and plastics industry washing waters in particular increase COD, whereas they don't affect BOD at all.

The river water is IV. quality in terms of total amount of phosphorous. The spatial homogenous group analysis done for the averages of total Phosphorus divides into 2 groups. Especially the fertilizers containing phosphorus or the detergent containing waters mixing into the river are expected to happen more in 5, 6, 7, 8, and 9. months, which constitute the second highest group. 50% of the phosphate in the wastewater comes from the domestic and industrial wastewaters, whereas 91% of the phosphate in the receiving waters comes from domestic and industrial wastewaters and the remaining 9% from comes from agricultural fields. The increase in the summer months can be explained by the increase of the number of the blue-green algae that can assimilate phosphate from the air in the soil or the use of fertilizers with phosphate. When evaluated spatially, the TP value of the sampling points 3. – 4. is expected to be higher because of the factory. However, there is no change observed in the Total-P value, whereas COD value might have increased accordingly. In that case, either COD pollution is caused by a different industry, or the treatment system of the existing facility is successful at treating Total-P but not at the removal of the COD.

River water is I. quality for NO_3-N. The concentration of NO_3-N depends on the development of seasonal algae and plants. Therefore, the increase in the amount of NO_3-N during winter might result from the insufficient development of algae and plants during that time. During spring and summer, the algae and plants develop, and they consume nitrate a lot, so the amount of nitrate in the water decreases in these times. TKN is a parameter including organic nitrogen and NH_4-N. Temporal and spatial homogenous group analysis is put together under a single group. On the other hand, temporal homogenous group analysis of NH_4-N has 5 different groups. Decreasing during hot seasons and increasing during rainy seasons recommends that the organic substances with nitrogen is high in the surface waters, and also the conveyance of organic substance is less during the summertime, when the flow rate is lower.

Due to the correlation analysis results, pH of Riva River varies proportionally with TP. On the contrary, an inverse proportion was observed with NO_3-N. T seems closely related to many other parameters. There is an inverse proportion between the temperature and the statistical amount of DO and TKN. As the T of Riva River increases, the amount of DO and TKN decreases, and as the temperature decreases, these values increase. The T and EC and S are proportioned with each other as well.

There is an inverse proportion between DO and EC and S. The BOD and COD amounts varied of the DO.

The correlation analysis done for the river shows that the EC is proportional to the parameters that increase concentration, which are Salinity, TSS, TVSS, BOD, COD, and NO_3-N. The salinity values are 99% positively related to T, EC, and COD, and 95% positively related to BOD and NH_4-N. TSS values are positively related to EC, BOD (95%), COD and NO_3-N values. Because TSS includes TVSS, BOD, which is strongly related at a significance level of 99%, is

closely related to T, DO and EC. Moreover, TSS seems positively related to NO_3-N. Due to the correlation analysis, COD is positively related to T, EC, Salinity, TSS, TVSS, BOD, and NO_3-N, and negatively related to dissolved oxygen. TP is related to only pH of the river. Due to the NO_3-N analysis results, it is positively related to pH, EC, BOD, COD and NH_4-N. NO_3-N is the final product of the oxidation of NH_4-N existing in the water. In these terms, the analysis is meaningful. Though expected in the analysis, there is no strong relation between TKN and NH_4-N. In that case, it can be said that the amount of organic nitrogen is relatively higher than NH_4–N, and therefore they cannot be interrelated statistically.

Conclusion

As general The River takes its place in III. and IV. level polluted/very polluted water group due to Turkish Water Pollution Control Act. The most polluted of the river is the 1. point which used to host the wastewater treatment plant. The point is polluted due to the Phosphorus, Nitrogen, BOD parameters in particular. Due to the microbiological analysis of the water, the Total Coliform, Fecal Coliform and Fecal Streptocossus parameters are higher, which might be a result of domestic wastewater, than the averages of Water Quality Classification. This situation requires the control of the last precipitation unit of the treatment plant. Furthermore, the necessary precautions are needed to be taken to decrease the amount of microbiologic pollutants, and also the chlorination and disinfection units must be operated. Agricultural activities being performed within the area causes phosphorous compounds, so the use of fertilizers and pesticides must be regulated and controlled. Establishing sewerage system at the sites along the river would provide minor wastewater treatment facilities. Especially the wastewater treatment plants of the industrial facilities between the points 2-3 and 3-4 must be well monitored. Urgent restoration needed for The River. İincreasing pollution would affect the biological variation negatively and threat the environmental health as well.

References

1. *Ceyhan M.,* The Eutrophication in Omerli Dam and The Effects of The Connected Rivers on Its Reservoir, Graduate Thesis, G.Y.T.E Institute of Engineering and Sciences, 55, Kocaeli, 1999.

2. *Akkaya E*. The Tendency Towards Pollution at Omerli Basin and Application of Phosphorus, Graduate Thesis, Yıldız Technical University Institute of Sciences, 25-37, Istanbul, Turkey, 2003.

3. *Pala B.* Evaluating the Water Quality of Omerli Reservoir, Graduate Thesis, Istanbul Technical University Institute of Sciences, 3-5, Istanbul, 1994.

4. *TSE*, Water Quality – Determining The Total Amount of Solid Substances TS 7093, 4, Ankara, 1989.

5. *APWA*, AWWA, WEF, Standard Methods for the Examination of Water and Wastewater, 21th Edition, Washington, 2005.

6. *Turkish* Water Pollution Control Act, Ankara, 2004.

Надійшло до редакції 25.11.2016