

Survey the Coliform Pollution in an Iranian River: the Safirood River of Maragheh City

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ABSTRACT

In this survey, in order to study the coliform pollution from surface layer of Safirood river in Maragheh city, East Azerbaijan, Iran, a quarterly sampling has been conducted during a year (2011-2012) in eleven stations with fifteen replicates. The pollution was completely examined by ENDO standard diagnosis method of Coliform. The results showed that, the highest pollution has been in the exit of village (Ashan). The highest Coliform count was seen during summer amounting to (28.5) coliform in 100 cm³ and fecal coliform (*Escherichia coli*=9) in 100 cm³ river water. In summer season, due to the high temperature, growth of bacteria was/is more than ever and furthermore, in the delta area because of calm flowing of water, it is passing through the city and agricultural centers and also entering garbage into it, the amount of pollution has been apparently reached a high level in comparison with other parts of the rivers with rapid flowing of water. From the results of this study, it was concluded that a considerable control of coliform pollution in particular in summer season along with mentioned effective factors is required to Safirood river of Iran to produce more natural and drinking waters and it can be considered as a protective strategy in all city rivers of globe for reduce the negative effects of infectious *E. coli* on people.

KEYWORDS: Pollution; Coliform; Safirood River; Maragheh City.

1. INTRODUCTION

Present microorganisms in water not only does lead to nutrient cycling in the water but also can produce other adverse events in natural and drinking waters. Coliform source usually is human and animal feces and is abundant in nature. Their excessive amount in food and water supplies are too dangerous and can cause poisoning and bowel diseases [1, 2].

Coliforms are divided into two categories, Non-fecal and fecal coliforms. The fecal one simply lives in the intestine, but some coliforms not only are seen in the intestine but also in the soil and on plants. *Escherichia coli* is one of the coliforms that exist in large numbers in the human intestine and its presence in water, food and the environment is due to fecal contaminations [2].

Rivers as one of the most important habitats of freshwater aquatic are among those ecosystems that have received little attention. Organic contaminants entrance from industrial, urban and agriculture wastewater (chemical and animals fertilizers) to aquatic environment enhances the biochemical demand via BOD oxygen from the materials are entered into the decomposition and transformation region [3, 4]. Then aerobic bacteria consume oxygen for decomposing the materials in. Regarding to increment of organic and contaminated material which have to be decomposed in the environment, bacteria consume large amount of the environment's oxygen [5,6]. As a result, the amount of dissolved oxygen in water is greatly reduced, and consequently leads to disrupt the aquatic life. Entrance of chemical fertilizers, pesticides and industrial, household and hospital waste into water sources not only are a serious threat to water resources in Maragheh city but also due to circulation rate of pollution, has led to serious challenges in the nature of the province [7].

Survey of Iran river-shave almost been started since two decades ago. Some subjects such as comprehensive biology and non-biology reviews of Safirood [8], Gorganrood [9] and Havigh [7] Rivers, hydrology and hydro-biology reviews of Haraz [10], Kheirrood [11], Shirrood [1], Chaloos [12] and Siyahrood [13] rivers, biological resources of the Siyahdaevishan and Pasikhan rivers [4, 6, 9, 14] and environmental impact of fish farms on Jajrood [15] and Tonokabon [16] rivers' pollution have been studied on the rivers of Iran in research centers. The purposes of these studies have been identifying and preserving the aquatic food chain of river ecosystems and classifying environmental identification, Identify sources of pollutants and the rivers' importance of agriculture and aquaculture. Aquatic ecosystems balance all its components to provide the groundwork for the development of aquaculture activities [14, 17, 18] and any change in it done by people either consciously or unconsciously destroys the balance and removes it from its natural state. And consequently, it's damage affects fish and eventually human.

The objective of the study is to investigate coliform contamination resulted from entering the agricultural pollutants, municipal and industrial wastewater in Safirood River located in the west of Maragheh city.

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2. MATERIAL AND METHODS

Maragheh Rivers, mostly originating from the southern slopes of Sahand Mountain, after traversing steep slopes and high hills arrive Miyandoab plain, then directly or indirectly discharges to Urmia Lake. The Rivers due to geographical location and specific hydrology have different ecological conditions from each other which are known as a river ecosystem. Safirood river originates from southeast heights of Sahand mountain and after passing its route, near the village Alaviyan divides into smaller branches and a twig goes to Alavian Dam and after gathering the water it overflows into the river which goes straight to the Urmia Lake.

The river is located in 46°25' 46' east longitudes between 37° 11' and 38° 28' north latitudes ,120 km southwest of Tabriz and in the Maragheh city region. Samplings from the river are conducted seasonally at least once every season from the 11 stations. The stations in the study were elected from upper, middle and estuary of the river. Sampling is conducted on the surface and sediment (river-bed) of the river (Sterile sample containers were immersed in water then the glass lid was opened under sterile conditions. Under any circumstances sample should not be touched with the sampler's hand before entering into the bottle. Sampling has done from the surface layer and the river-bed). Noteworthy, the samples in sterile conditions and at a temperature of 4 ° C in ice flask in less than 24 hours were transferred to the laboratory and bacteriological studies of the bacterial cultures were performed.

Experiments were conducted using total bacterial count method involves the following step [19-21]:

Preparing ENDO growth medium:

Seventeen grams of ENDO growth medium is solved in 0.5 Liters of water and for 20 minutes the solution is put in an autoclave with 1 atmosphere pressure. The prepared medium is spread on a petri dish. Then filter is put on it without remained air under it. This is done for every 5 samples on a Petri dish. Diluted samples are passed through the minimum 2 or 3 grade filter. After a period of 2 to 3 days of incubation at 27 ° C achieved colonies are blue - red - yellow - orange which coli coliform are. It explained that if the filter is grade 3one it will leave up to 35 colonies and if the grade 2 filters are utilized 350 colonies will be leaved up.

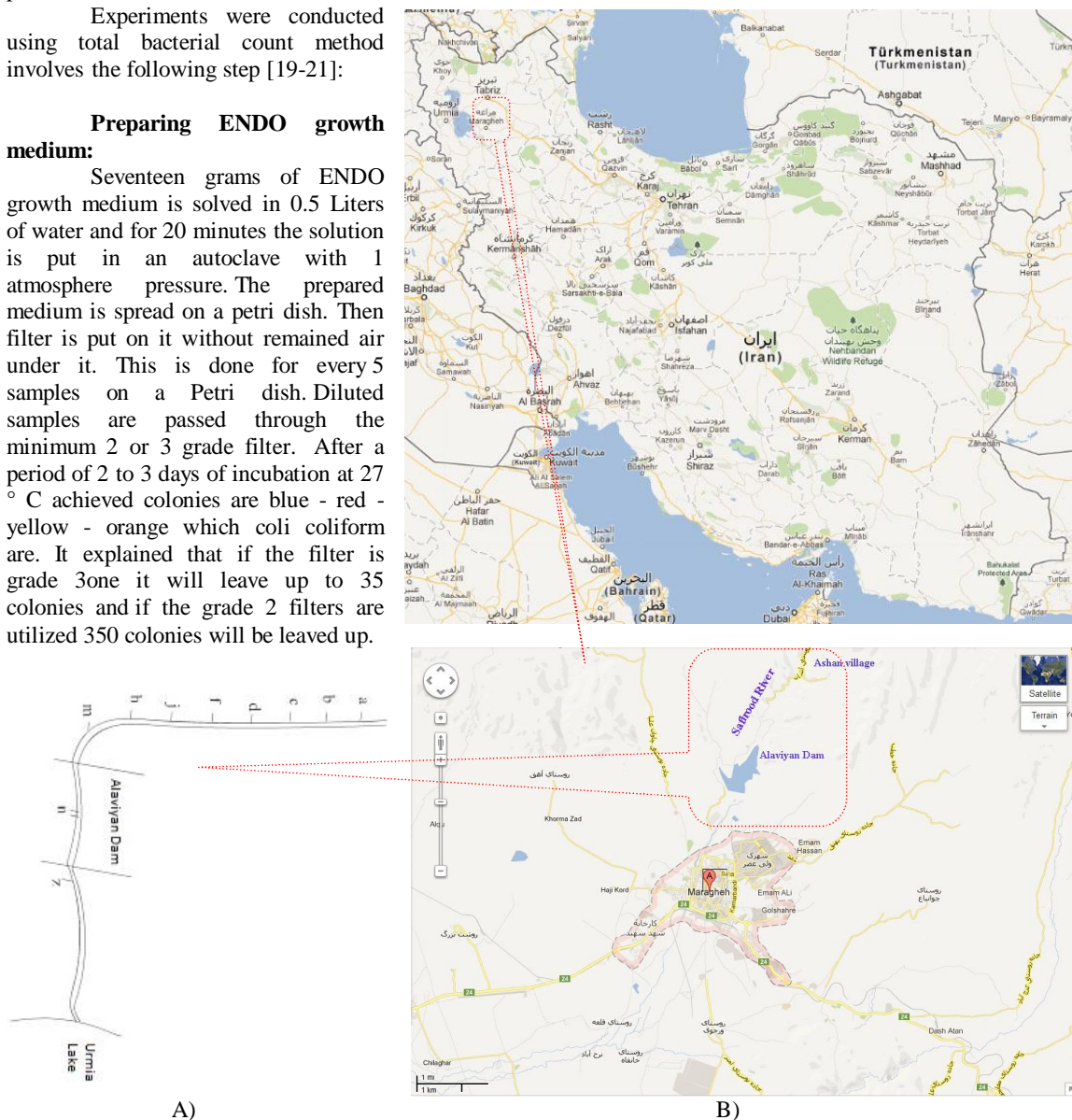


Figure 1. Geographical location of study stations of Safirood River (A), Maragheh city (B), East Azerbaijan, Iran
 A) The study area is magnified in the left side of map. "a-z" are sampling points of coliform pollution.

Statistical analysis:

Based on the one way analysis of variance (ANOVA) bacterial contamination differences in terms of the different stations, seasons and the depth of surface and sediment are significant ($P < 0.05$).

3. RESULTS AND DISCUSSION

In terms of ecosystem, there are various conditions along the route. In upstream it is rocky with cobble stone but near the mouth, it is sandy and water flows slowly. Water in the exit of all the villages along the route of river is more contaminated then as it enters to the villages [22- 24]. It shows that during the crossing of the village wastewater can be found increases microorganisms' volume. This is due to the change of living conditions in the river bank [25-27].

Bacteria proportion in spring generally was more than in winter and autumn; the reason for this is that the spring rains and melting snow are washing bacteria generally founding in soil into rivers and causing overall bacteria increasing (Table 1). The total amount of bacteria in the summer season is even more than other seasons even spring due to increased evaporation, reduced flow rate and increased temperature of water and reducing amount of oxygen that has led to an overall increase of bacteria. In the z, n, m points, the transparency of water and also oxygen amount are higher so, it results fewer overall bacteria amount than other stations in the area (Table 1). 25 years ago wastewater discharge into ponds was not a serious issue and natural process has been largely able to compensate it but now with the increase in population and urbanization, various industrial activities such as fish farm construction and subsequently discharged waste water from them, in most cases, the natural process are unable to offset perturbations.

Table 1. Coli coliforms of 11 stations in seasons of a year

Seasons	Winter	Spring	Summer	Fall
Sampling Points	Escherichia coli in water			
a	12	24	14	12
b	17	31	40	26
c	18	24	35	22
d	13	27	25	23
e	13	18	29	14
f	16	26	38	19
j	13	29	27	23
h	15	16	32	26
m	21	24	35	13
n	18	23	33	11
z	14	17	26	15

Table 2. Fecal coliforms of 11 stations in seasons of a year

Seasons	Winter	Spring	Summer	Fall
Sampling Points	Coli bacteria			
a	3	5	6	3
b	8	11	10	7
c	2	4	4	3
d	4	5	4	3
e	5	6	8	5
f	8	10	12	6
j	4	7	5	4
h	7	9	8	8
m	3	3	6	4
n	2	2	4	3
z	4	4	5	5

According to the results obtained from microbial investigation of the Safirood in the study (Table 2), the maximum fecal coliforms contamination in the river was in the river mouth with 40 numbers in every 100 centimeter cubic in the summer. It has been approved that reduction in water temperature, increase flow rate with the rapid conditioning because of high flow rate of water and the absence of contaminants sources make the amount of dissolved oxygen favorable. With the increase in water temperature and reduce the flow rate of water because of use on farms the amount of dissolved oxygen decreases [14]. In areas where water has high flow rate and rapid transitions because of a well conditioning consumed oxygen compensated through water contact with air and often there is a good natural treatment condition. This is the reason that in all the studied rivers, there were fewer pollutants in the all stations that water flow rates were high than the river mouth that has lower flow rate.

Also, rivers' passing through urban centers and entering their waste into the rivers cause marked changes in the pollution factors of them. Likewise, household waste at the edge of the rivers' coasts and the use of chemical fertilizers and animal manure on agricultural lands make more water pollution.

When a river flows slowly and its flow strength reduces, a part of its suspensions begin to sink. The excess nutrients in the sediments as the ionic load reduce water depth and nurture immersed plants [17, 22]. Also, in the river's soft and muddy bed which is due to a gentle stream of water, bacteria can easily be settled. So, much of contamination is in sediment rather than water surface. Rapid water flow and transport in the upstream (stations 4 and 5) wash organic materials and bacteria's live environment and bring to downstream (river mouth).

According to a report [28] prepared by the Environment Department of Alabama about the Flint river located in the Alabama state of USA which studied the river's fecal coliforms contamination in the 1999, in the river's mouth, which its speed is low and there are residential areas, the number of fecal coliform colonies per 100 ml of water was reported in 2000 that is indicative of high pollution. Also a similar report about Rocky River in northern California in America in 1998 is presented (values not stated) [quoted from 28]. Industrial solid discharges and agricultural activities in the watershed can increase the sediment load in the river. Fertilizers use for strengthen the plants used to restore the plant must be controlled because a part of the broadcast fertilizers can be absorbed by plant roots and the rate of flow of the sand layers are underground and surface water.

Water and air temperatures change along the river way have a decisive role in the spread of aquatic organisms and microorganisms due to their effects on natural selection conditions and the effect of water temperature on the solubility of oxygen is important [29, 30]. The effect of temperature on microbial growth mechanism is complicated. This mechanism can simply be presented as the result of two types of activities. Rate of enzymatic reactions such as chemical reaction rate changes with temperature. The reactions rates are low in the low temperature and rise as the temperature rises. Decomposition processes in proteins and enzymes is very slow at low temperatures.

The highest temperatures of weather and water belong to the summer and the spring and the lowest is for the winter (Table 3). Temperature increasing makes proper environment for coliform's growth, its result is increased metabolic activity and also, with increasing water temperature, the solubility of oxygen becomes too low. Biomass and total number of bacteria in rivers depends on the temperature. So, in a relatively polluted the German Bayan river in the summer maximum coli infection have been reported. Shallow and covered watershed areas in the fast flowing rivers naturally has high potential and capacity for digestion and assimilation of industrial and domestic wastewater. Municipal wastewater to a certain degree before discharging them into the river can be used as a complementary treatment that utilizes the power of the river.

Table 3. Values of temperature during different seasons and range of determining physiochemical factors' change in river Safirood River

Water quality parameters	The standard range	Range of changes
Do mg/l	> 6	8.5-11
BOD ₅ mg/l	Clean 0-2 fairly polluted 3-5 extremely polluted >5	1.4-217
Water Ph	6.5-9	7.6-8.1
No ₃ mg/l	Maximum 1	0.08-0.5
Nh ₄ mg/l	Maximum 1	0.04-0.35
Po ₄ mg/l	Maximum 0.1	0.1-0.5
Season	Weather temperature °C	Water temperature °C
Spring	16.9	15.3
Summer	23.7	19.4
Fall	7.1	5.5
Winter	1.6	4.2

Sand moving leads to the loss of these shallow beds and reduces their improving capacity, Thus, the difference comes in the depth of water and It also severely makes the river muddy which these factors are barriers to fish migration, on the other hand the indiscriminate mining of sand causes loss of many aquatic organisms, such as insects, crustaceans, mollusks, and etc. that are the fish food.

If feeding habitat is under threat the organism can be protected in certain places and it was hoped to survive generations. But when animal's breeding sites are destroyed, even with ideal feeding habitat cannot guarantee their sustainable survival. As a result, fish and baby fish will disappear.

The results showed that due to the river discharge, the concentration of PO₄, DO NH₄, NO₂, NO₃, BOD₅ and pH according to Table 3 were in the standard limits. BOD₅ increase in the summer according to the standard values, in the Safirood River deltaic area has been 2.7 milligrams per liter. It indicates the minority of the contamination resulted by a decrease in water in the growing seasons, the river bed manipulation, existence of residential areas, wastewater influence and waste disposal.

The study shows that the effect of the river coliform pollution is lower than the standard so it makes no significant changes on the river's regime and water quality (With respect to the standard table of Environmental Protection Organization in 1999 [31, 32], fecal coliform in discharges to surface waters is 400 per ml; in discharge to the absorbing wells 400 per ml, for agriculture and irrigation is zero and coliform in surface water discharge 1000 per ml; to the absorbing wells 1000 ml, for agriculture and irrigation 1,000 per ml).

Nowadays, the rivers' problem is indiscriminate human interference in the ecosystem which has serious consequences and will have irreparable losses to the environment [33]. The River, in the not so distant past, was a fisheries hatchery and had economical values but because of the frequently removal of the sand, the natural state changes and industrial and urban pollutions somewhat the river has lost its ecological dynamics [34]. And the continuation of this trend could establish nuisance conditions for the aquatic.

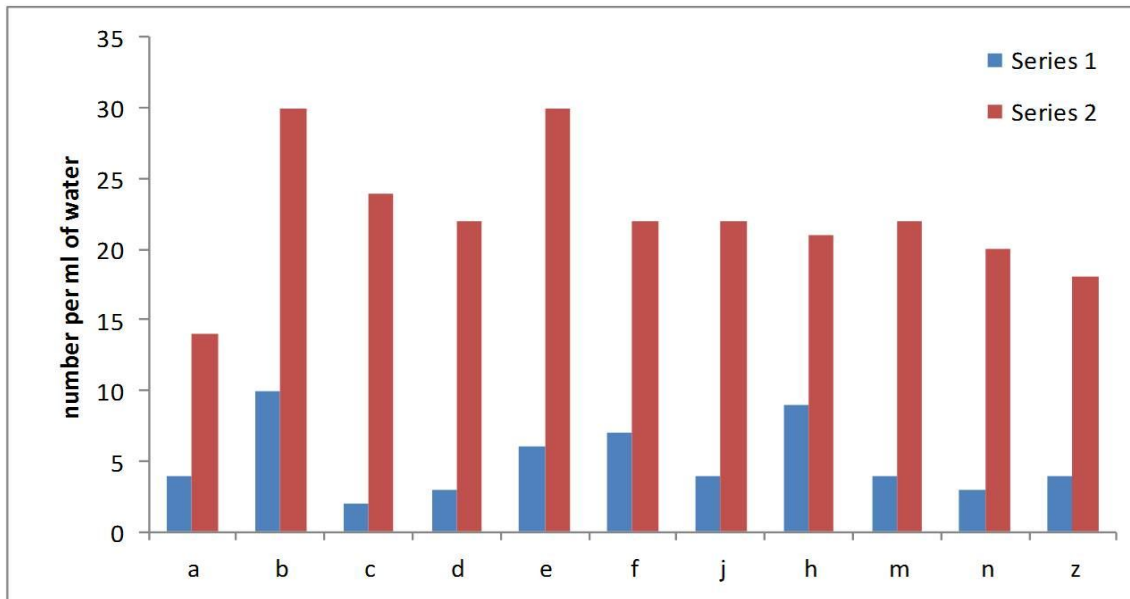


Figure 1. Contamination of coliform and fecal coliform (*E. coli*), the Safirood river by the Maragheh city stations (Series 1= fecal coliform; Series 2= Total coliform)

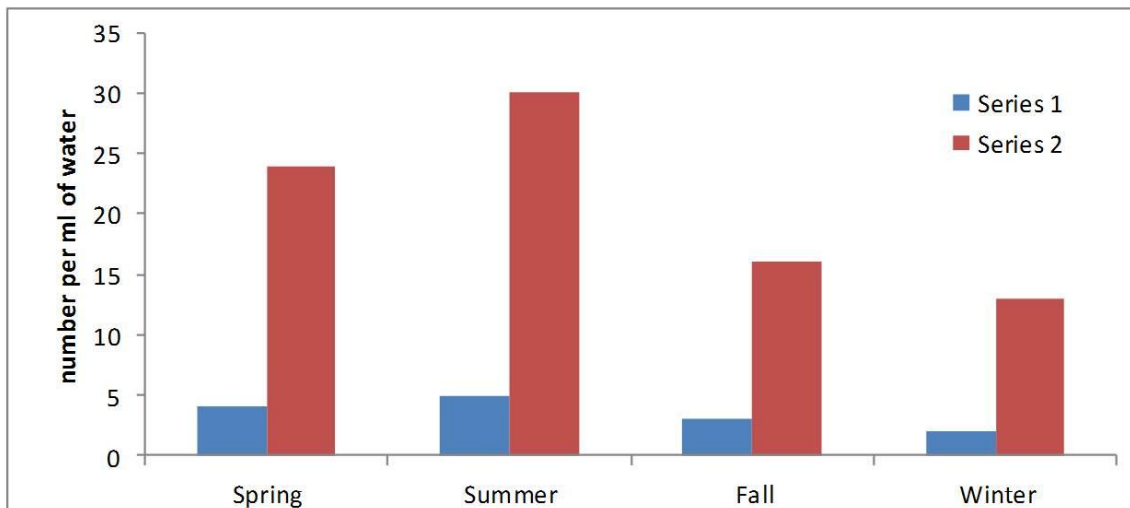


Figure 2. The coliform and *Escherichia coli* contamination of the river in the Safirood river of Maragheh city by the year (Series 1= fecal coliform; Series 2= Total coliform)

4. CONCLUSION AND RECOMMENDATION

Coliform and fecal coliform pollution results are shown in tables (1, 2 and 3) and charts (1 and 2). As shown in figure 1, the highest average of coli and fecal coliform pollution are 28.5 and 13.125 pcs in 100 cubic

centimeters of the station B and the lowest average of coliform and fecal coliform pollutions are 14.25 and 9.625 pcs in 100 cubic centimeters of the station 4. As shown in Figure 2, the highest coliform pollution mean in summer was 44.2 coliform per 100 cubic centimeters and highest fecal coliform pollution mean in summer was 22.1 fecal coliform per 100 cubic centimeters and the lowest pollution was observed in winter. As seen in figure 3, in sediments the highest coliform and fecal coliform pollutions means are 58.25 coliform and 20.45 fecal coliform per 100 cubic centimeters.

As a consequence, in summer season, due to the high temperature, growth of bacteria was more than ever and furthermore, in the delta area because of calm flowing of water, it is passing through the city and agricultural centers and also entering garbage into it, the amount of pollution has been apparently reached a high level in comparison with other parts of the rivers with rapid flowing of water. From the results of this study, it was concluded that a considerable control of coliform pollution in particular in summer season along with mentioned effective factors is required to Safirood river of Iran to produce more natural and drinking waters and it can be considered as a protective strategy in all city rivers of globe for reduce the negative effects of infectious E. coli on people.

AKCNOWLEDGMENT

It was summarized from PhD thesis and support of Azerbaijan National Academy of Sciences, Microbiology Department, Baku, Azerbaijan is gratefully acknowledged. At the end, I intend to express my gratitude to research supervisor, Prof. Dr. Memed Salmanov with his valuable assistant in all steps of study.

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