Control of Drinking Water from the Central Water Supply System of the City of Tetovo in terms of Physico - Chemical Safety

Environment

Keywords: quality, physico-chemical, water, urban water supply.

Dijana Jovanoska	PHI Center for Public Health, Tetovo – Macedonia.
Marija Krstovska	PHI Center for Public Health, Tetovo – Macedonia.

Abstract

Objectives: The objectives of this paper is an examination of the physical and chemical characteristics of drinking water from the central water supply facility in the city of Tetovo, which uses water from four Shara springs in order to evaluate its quality in accordance with the prescribed norms. **Methods:** hygienic safety of drinking water in the city is followed by an examination of 12 parameters of 22 samples per month, twice a week from 19 measuring stations in the city in a period of 01.01.2011-31.07.2013. From one measuring point, in average, are taken over 30 water samples. The temperature and the concentration of free chlorine measured in the field (in situ), while other parameters (color, smell, taste, turbidity, permanganate consumption, pH, electrical conductivity, ammonia, nitrites, nitrates, chlorides and iron) are monitored in laboratory testing of water and food at PHI CPH Tetovo. Meanwhile, there are used accredited, ISO standard methods, as well as spectrophotometric HACH methods which are USEPA accepted. **Results:** Based on the analysis performed on a total of 860 samples, only 15 were defective samples or 1.74%. An analysis of all parameters is condacted for all measurement locations where the samples were taken, and their minimum, maximum and average values are represented graphically and in tables. **Conclusion:** According to the obtained results, the city water fully meets the norms in accordance with the legal regulations which include this city in one of the fewest that today drink pure, unprocessed, spring water.

1. Introduction

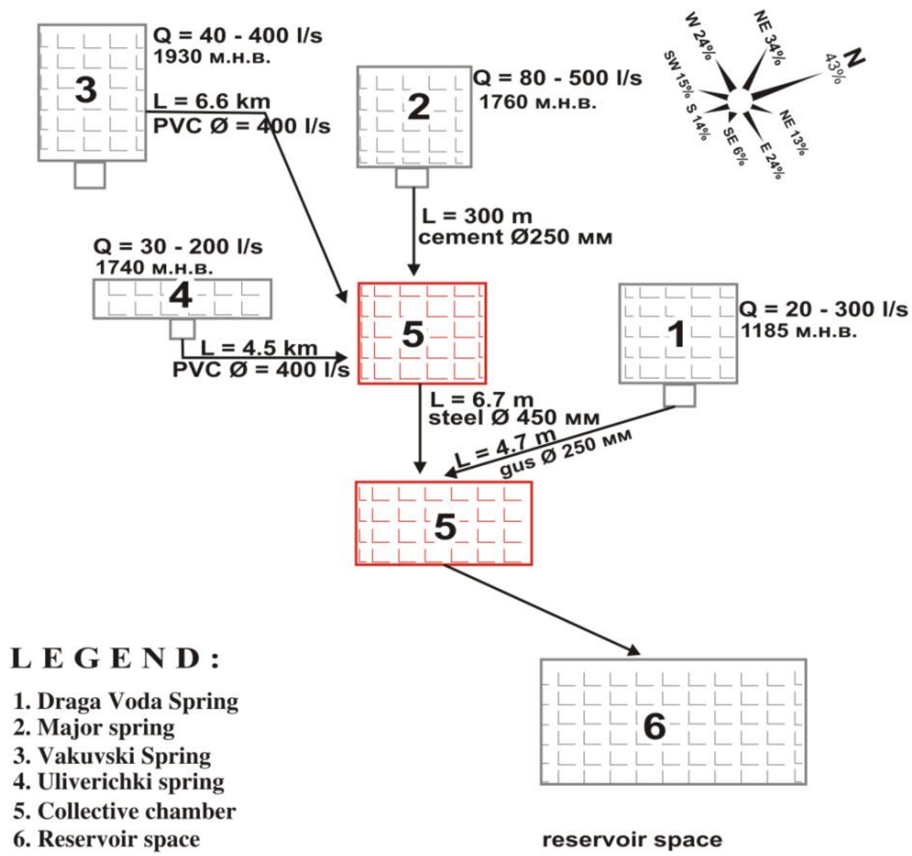
Tetovo is located in the middle of the Polog plain, at the foot of the Sharr Mountain, hostile on the shores of the Pena River. Most of the city extends in the plains, and only a small part lies on the slopes of Baltepe, 806 m high hill. The absolute altitude of the city is 450 m.

The water supply of the city of Tetovo is done by way of gravity from the water supply system Popova Shapka - tanks Tetovo. The first water supply was built 1929 (Dear water - tanks Tetovo). The main pipeline, Popova Shapka - tanks Tetovo is constracted 1956 and additions were made in 1965, 1973 and 1981. The water supply is connected to 22405 households and commercial buildings in 2030 or approximately 85000 residents. Annually, through it pass 9 million m3 of water. Water supply is carried out from following 4 sources:

- Draga Voda Spring (1185 altitude, 20 30l.sec)
- Major Spring (1760 m, 80-500l/sek)
- Vakuvski Spring (1930 m, 40-400l/sek)
- Uliverichki Spring (1740 m, 30-200l/sek)

Considering these data the aim is to examine the quality of the water whic citizens of Tetovo drink, which will give an insight as to the quality of the spring water, as well as the impact of water supply on its final composition.

Situation plan - Sketch of springs and intake ;



2. Materials and methods

In the period between 2011 - 2013, 860 samples of drinking water are analyzed taken from 19 measuring stations in the city, twice a week. This means that every month 22 samples of water were taken. For each sample of each measuring point analyze is done by 12 parameters including: temperature, free chlorine, color, turbidity, pH, consumption of calium permanganate, electrical conductivity, ammonia, nitrites, nitrates, chlorides and iron.

The physical properties of water (taste and smell) are registered with the senses or can be measured without changing its properties [1]. Temperature and free chlorine were measured in the field, and all other parameters are analyzed in the chemical – bromatologycal laboratory at PHI Center for Public Health - Tetovo. From the moment of sampling to the time of their analysis do not spend more than 4 hours.

Turbidity is determined by using a nephelometric turbidimetar HACH 2100N IS which is designed to measure turbidity in water according international standard for measuring turbidity ISO 7027, DIN 38 404 i NF EN 27027 [2].

pH is measured electrochemically using the HANNA pH meter according to ISO 10523:2008 [3].

Consumption of calium permanganate si done according to the method of Kubell-Tieman, method of boiling sulfuric acid [4,5].

The electrical conductivity is measured using conductometer OAKTON PCD 650 EUTECH instruments, accredited method ISO 7888:1985 (EN 27888:2007) [6].

Ammonia is determined spectrophotometrically using the method Nesler. For this purpose it is used spectrophotometer HACH DR 5000 HACH method 8038 [7].

Nitrates are spektrofotomotrically measured with HACH 8171 method, nitritse according to HACH 8507, chlorides HACH -8113, iron HACH 8008 [7]. All spectrophotometric methods are internationally or USEPA accepted.

The measurement points are shown in the table below:

Measuring point	Number of measuring points analyzed samples	Measuring point	Number of measuring oints analyzed samples
1. Religious building	26	10. Public Fountain Zhicara	36
2. Objects around militaru barracks	50	11. Religious building-Eski Mosque	29
3. PS Bratsvo Migjeni	31	12 Kindergarden -Potok	30
4. PS Naim Frasheri	31	13. Public Fountain –Dva Bresta	34
5. Ambulancy Monopol	26	14.Spring Bazelova	28
6. Religious Building(Mosque) Sub. Drenovec	30	15.Secondary School Nikola Shtejn	54
7. Railway Station	38	16.Kindergarden Teteks	54
8. Confectioner's Shop Rinija Sub. M.Rechica	46	17. Catering object	47
9. PHI CPH-microbilogy	70	18. Hall of ARM	48
19. Undesinfected water - Tank	124		

3. Test results

The temperature of drinking water moves from 5-9 0C, while the concentration of free chlorine is 0,1-0,2 mg / L. The values for the maximum, minimum and average values of all other parameters analyzed samples taken from all 19 measuring points are given in the table in Appendix.

3.1 Color

The color is organoleptic parameter that indicates the possible presence of organic or mineral substances of natural or synthetic origin which may be undesirable in the present form and may cause consumers, ie consumers to decide for other water.

In 2011, 358 samples of water were analyzed from the central city waterplumbing in which 6 samples (1.7%) were defective, and 4 of them, or 66.7% did not meet the criteria for color, which according to the

Regulation of water safety should be maximum 20 [8]. In 2012 from total 354 analyzed samples there is not any defective in terms of this parameter, which was confirmed in 2013 where all 148 water samples showed less than 20 color units according Pt-Co scale.

3.2 Turbidity

Turbidity is also organoleptic parameter derived from various unsolute components present in the source water or due to additional precipitation in the network or corrosion [9]. The maximum allowable concentration for turbidity (MAC) is 1,5 NTU [8]. Measurements are made using turbemeter. Namely, by passing a beam of light through the analyzed sample comes to its violation as a result of his collision with unsoluted particles.

In 2011 out of 358 samples, 6 are defective, or (1.7%) and all 6 (mean 100%) due to elevated turbidity. In 2012, out of 354 samples, 4 are defective, or 1.13%, of which 3, 75% are defective due to elevated turbidity above the MAC. Similar is the situation in 2013 when for only 6 months, from 5 defective samples even 4 or 80% did not meet criteria for turbidity. Change of the turbidity is shown graphically in Figure 2. From the image can be clearly seen that the minimum values ranging from 0-0,2 NTU, and maximum values are in the range of 0.9-2,9 NTU. The image shows that the highest turbidity shows water measuring 19 th place, and this is the tank where water collects and is not desinfected. Increased turbidity show also measuring points 2 and 18, and these are measurement places where occasionally water from nearby wells joins, which immediately alarm that water from these measuring points is with slightly altered composition than usual when using only spring water. However, analyzing the average values can be noticed that all are moving around 0,6 NTU far from the MAC.

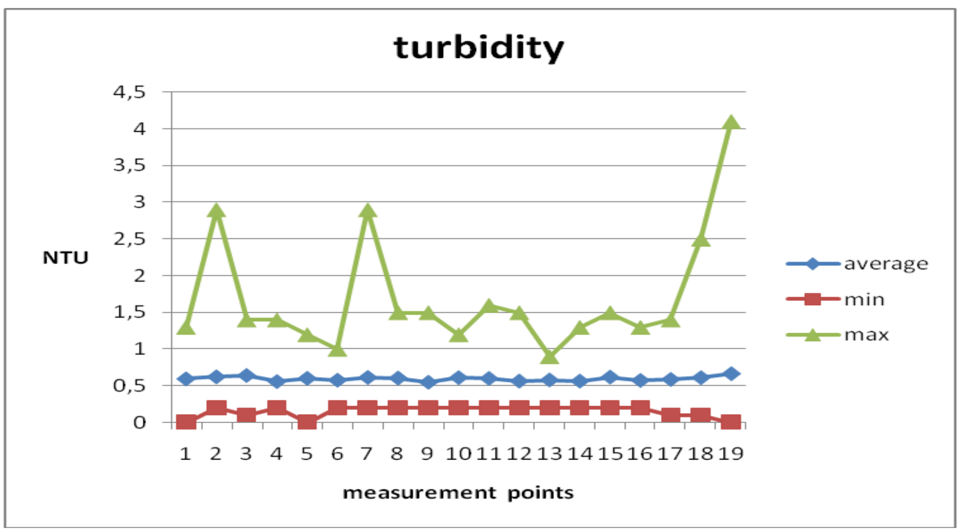


Figure 2: Graphical Representation of the Turbidity Change by Measurement Points

3.3 pH

pH value affects the corrosion and is correlated with alkalinity, hardness, temperature, absorbtion and efficiency of coagulation, chlorine disinfection, precipitation of metals etc.. In Tetovo city water in 2011, 2012 and 2013 all 860 samples had satisfactory pH values [8]. From the graph can be easy visible that neither maximum nor minimum values do not exceed the prescribed legal norms, while the mean value of pH ranges from 7,8-8.1

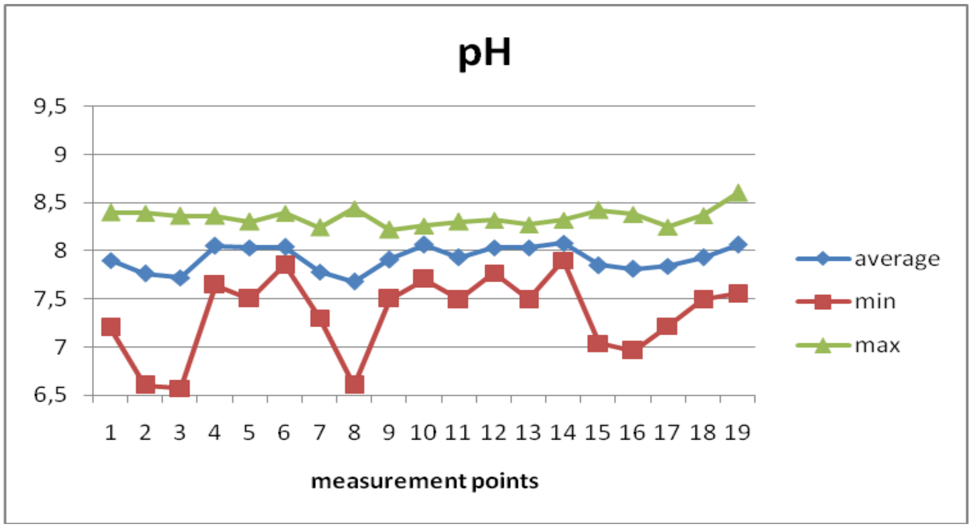


Figure 3: Graphical Representation of pH Changes by Measuring Points

3.4 Consumption of Calium Permanganate

This parameter is a global measure of organic matter that is an excellent base for development of microorganisms and changes in water quality. The permanganate is oxidizing the ternernite compounds, with the exception of nitrogen ones from plant or animal origin. Under the legislation, MAC for this parameter is 8^{th}. In Tetovo city water in 2011 out of 358 samples analyzed, 6 were defective, or 1.7%, and 4 of them, ie 66.7% doesn't coresponding regarding this parameter. In 2012 and 2013 thre is no sample that is defective due to increased load of calium permanganate. The image shows the changes in the consumption of permanganate by measuring points for the specified period, a well as received the maximum, minimum and average values. From here it is clearly visible that the maximum concentrations ranging from 2.8 mg / l to 6.2 mg / l, which is all under the MAC. The average values are around 2 mg / l for all measurement locations without major deviations.

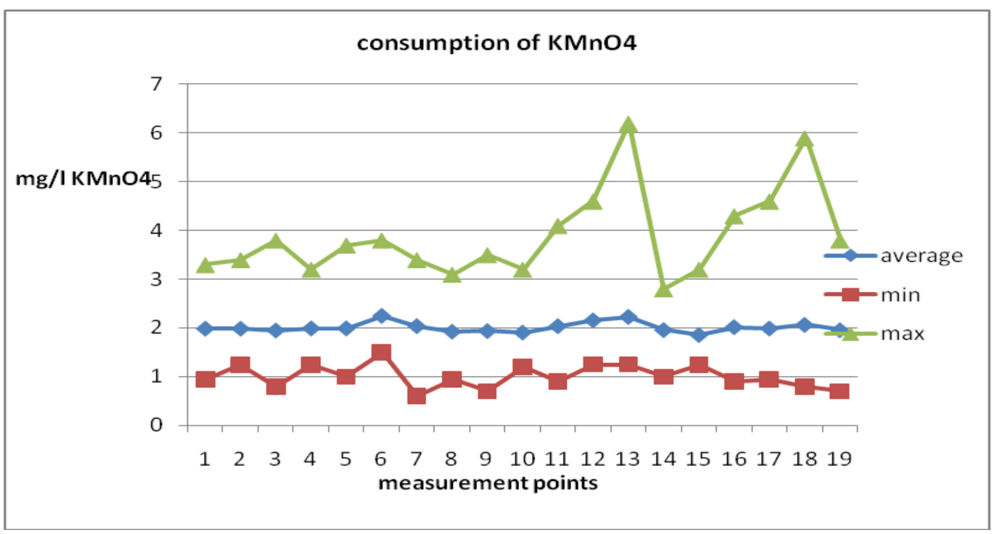


Figure 4: Consumption of Permanganate (mg / L) by Measuring points

3.5 Electrical conductivity

Electrolytic conductivity expresses the ability of water to conduct electricity. This ability depends on the presence of ions, their concentration and the temperature at which the measurement is carried out [1]. The measured values of this parameter in 2012 and 2103 in total of 502 samples were satisfactory, while in 2011, 6 defective samples (1.7%), only one (16.7%) unsatisfactory. The highest values were found in measuring points 3 (657) and 16 (671) which also occasionally, during low water use water from nearby wells (table attached)

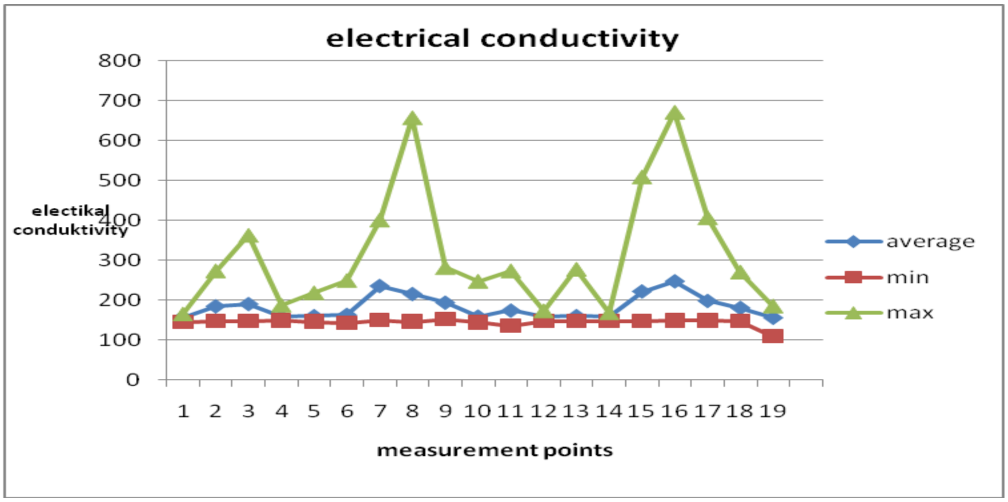


Figure 5: Change of Electrical Conductivity of Urban Water by Measuring Points

3.6 Nitric triaza (ammonia, nitrates and nitrites)

Ammonia resulting from the decomposition of organic substances containing nitrogen. According to the analyzed values for ammonia nitrogen in 2011, a total of 358 samples, defective 6 (1.7%), and only 4 of them (66.7%) did not meet the criteria for which the MAC is 0.5 mg / L. [8]. In 2012 there is no sample which had increased concentrations of ammonia, while in 2013 out of 148 analyzed samples only one was with ammonia value over MAC which is 20% the percentage of defective water samples in that year (3.38%). From the graph (Figure 6) clearly is visible that the maximum concentration of ammonia reaches 12:12 mg / l which is far from the MAC. (Appendix Table)

Nitrates and nitrites are an indicator of possible water pollution with organic substances. Nitrates are undesirable compounds in the water if they are with concentration above 50 m / l because it leads to increased methaemoglobin levels in blood of babies, which can lead to death as result of the reduction of nitrate in the mouth or stomach. Adults are protected due to the low pH values of gastric juices and the existence of specific enzymes that protect [9]. To clinical effects of methemoglobinemia comes even faster with nitrites and therefore their concentration is limited to 0.1 mg / l. [8]. To people with infected urinary tract (bladder) can lead to the formation of nitrosamines which may be carcinogenic [9]. Because of this it is important to monitor nitrates and nitrites in drinking water. In Tetovo city water for a period of 30 months observed are 860 samples of which only 4 samples (0.46%) with noticed concentrations above O, 1 mg / l nitrite and only one sample was with elevated nitrate concentrations above 50 mg / L which is an insignificant percentage of 0.1%.

From the graph (Figure 7) we see a peak for the 19 th measuring point, while all other values are within the limits of normal. Even we can observe that the average value is very close to the minimum and range from 0 to 0.003 mg / l.

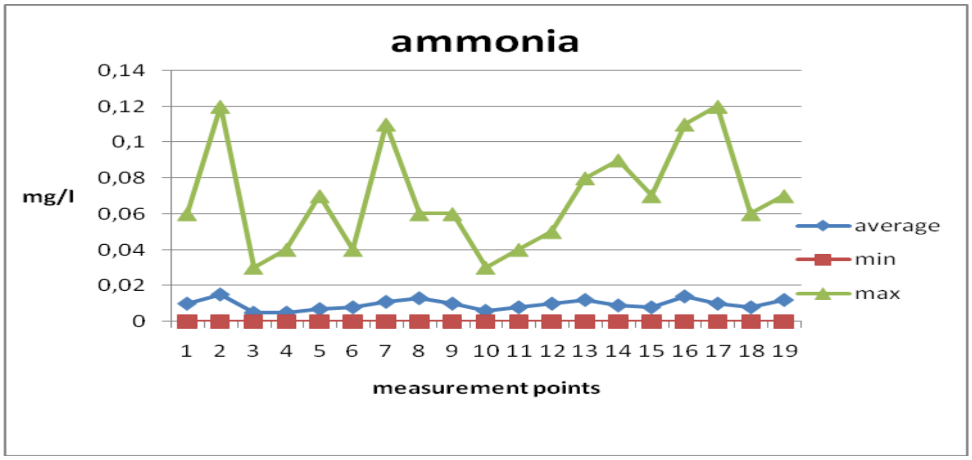


Figure 6: Measured Concentration of Ammonia (mg / L) by Measuring Points

As the concentration of nitrate (Figure 8) observed by measuring points, may be noted that the maximum concentration was measured in 16-th measuring point and equals 24.9 mg / l which is half of the MAC. Average values ranging from 0.64 to 3.9 mg / l. (Appendix Table)

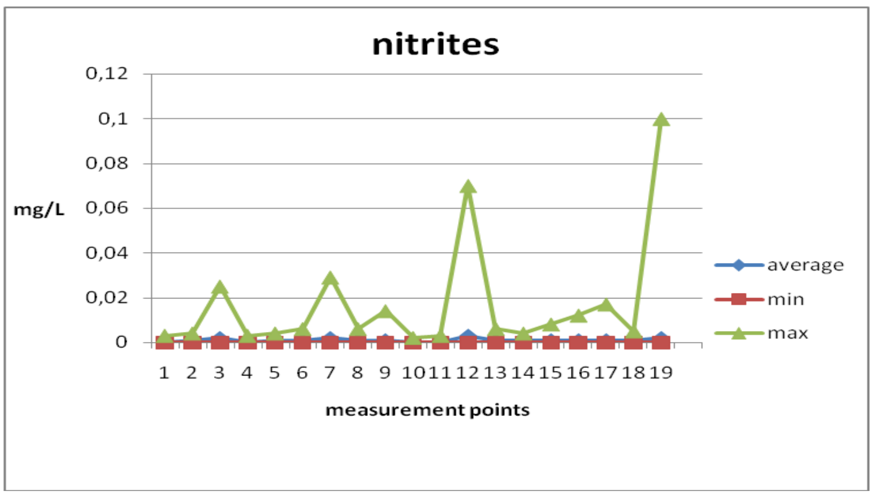


Figure 7: Measured Concentrations of Nitrite by Measuring Points

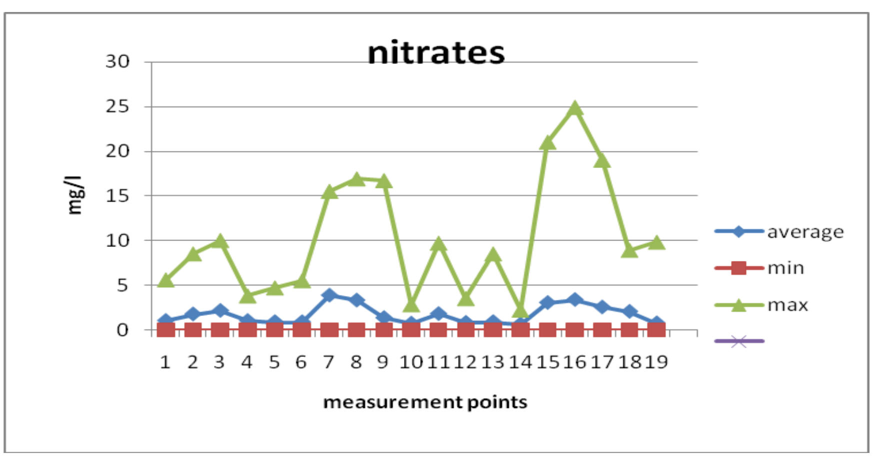


Figure 8: Concentration of Nitrate by Measuring Points

3.7 Chlorids

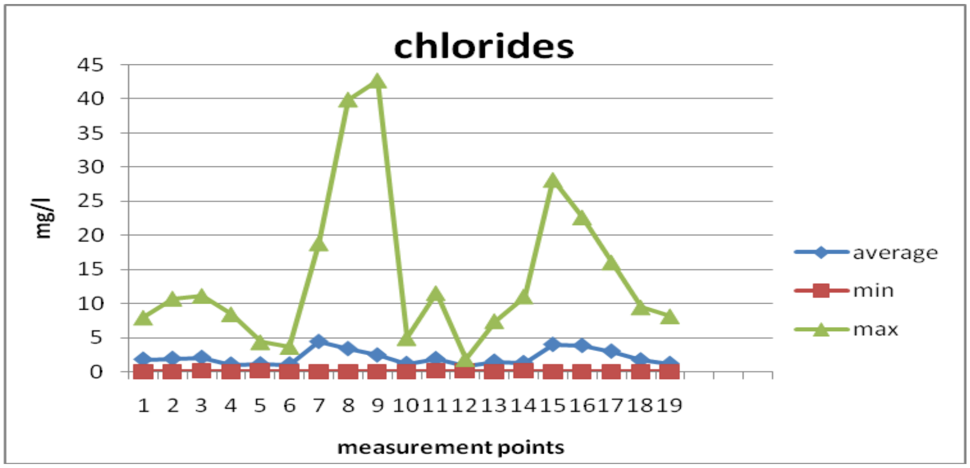


Figure 9: Concentration of chloride by measuring points

The concentration of chloride is limited to 250 mg / L and only because of their impact on the taste of the water. However, the increased values above MAC are sign of possible faecal or other contamination, and it can also act corrosivelly over metals. In the water from the central city water pipe in Tetovo out of 860 analysed samples, none is with detected concentrations above the MAC.

3.8 Iron

Iron is an essential element in the diet, but the maximum concentration of 0.2 mg / l is set for aesthetic reasons, because at higher concentrations may accrue in the network and cause change of the color. It occurs due to inefficient cleaning or due to corrosion of pipes.

In a period of 2.5 years, i.e from total of 860 samples, all samples from all measuring points are with a value below the MAC. According to the graph (Figure 10) can be noted that the maximum concentration is found in the water sample taken from the measuring point number 19 which is not desinfected water (table attached).

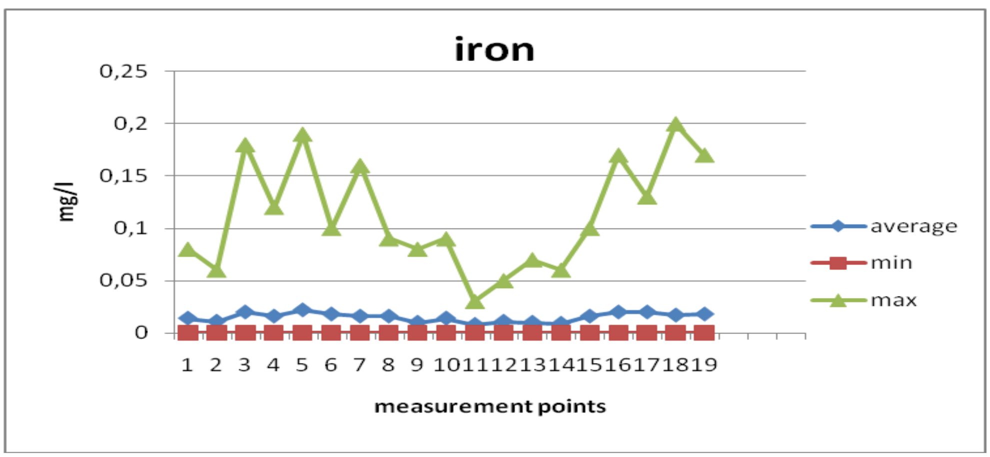


Figure 10: The measured concentration of iron by measuring points

4. Discussion

The monitoring of water quality for drinking from the central city water supply facility that receives water from four Shara sources presents satisfactory characteristics concening examinated physical and physico-chemical parameters in accordance with legal regulations. Measurements are made for a period of 30 months ie from 01.01.2011 - 01.07.2013 year. Analyzed a total of 860 samples of water are taken alternately from 19 measuring stations in the metropolitan area with approximately 30 samples from one measuring point (attached). Thus, out of 860 samples, 15 are defective samples, ie 1.74%. Most samples were taken from the measuring point 19, actually the tank. In this measuring point from where 124 samples are analyzed, can be noticed the increased values of the following parameters: turbidity, pH value and concentration of nitrite which is expected because it is untreated or undesinfected water. Also, it can be noticed a change in the values of ammonia, iron, Electrical conductivity and nitrates in measuring points 3, 5, 8 and 16 which is also expected because these measuring points occasionally, during low water, they use surrounding wells which change the composition of water from the city central water supply or water from the spring.

From all this, follows the conclusion that Tetovo water fully meets the characteristics of sound and quality drinking water. This proves that the water supply does not affect the taste and quality of water from these Shara sources. Consequently it can be said that although water is a profitable business and a growing trend today is its packaging, or purchase bottled water, which is a challenge of economic, social and health aspect [10], still it should be considered the fact that the growing consumption of bottled water creates millions of square meters of waste PET bottles worldwide. Bottled water is associated with a healthy lifestyle, but it is not proven that it is healthier than tap water supply. It is obvious that it is a profitable business, when we know that the cost of 1 m3 of water from the comunal system is about 20 denari which is much lower cost than 1L bottled water. Almost 40% of advertised bottled water, her life begins in the pipeline. At the end left only the recommendation to maximally exploit these wonderful Shara sources in order to provide sufficient quantities of drinking water in the city throughout the year, actually the gained results should be extra incentive for continuing research in terms of ensuring safe plumbing and safe drinking water.

References

[1] Божо Далмација; Контрола квалитета вода у оквиру управљања квалитетом, Природно-математички факултет Нови Сад, 2000.
[2] HACH procedure (according to ISO 7027:1999).
[3] ISO 10523:2008-Water vquality, determination of pH.
[4] Вода за пиќе-Стандардне методе за испитивање хигијенске исправности, Савезни Завод за здравствену заштиту НИП Привредни преглед, Београд 1990’.
[5] Практикум из броматологије, др. М.Мириќ, др. Д. Станимировиќ, Београд 1989.
[6] ISO 7888:1985 (МКС ЕН 27888:2007)-Water quality-determinaton of electrical conductivity.
[7] Standard methods for the water and wastewater examination, 20th edition,1998 (Hach 8038;Hach-8507;Hach-8113; Hach-8171;Hach-8008).
[8] Правилник за безбедност на водата, сл.весник на РМ бр.46/2008.
[9] Упореѓење неких прописа о квалитету воде за пиќе и осврт на значај параметара, проф. Др, М. Милојевиќ, Љ.Пјеротиќ, др. Б.Мирковиќ-Брус, мр. В.Мартиновиќ-Витановиќ, дипл.биолог В.Калафатиќ; Вода и санитарна техника 21(4)23-38(1991).
[10] Др. Војислав Ѓековиќ, Шумарски факултет Београд, Квалитет воде за пиќе и промет флашираних вода на тржишту Београда.