J. Int. Environmental Application & Science, Vol. 11(3): 277-284 (2016)

Assessment of Water Quality Index of Durresi-Kavaja Basin, Albania

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Received June 22, 2016; Accepted September 09, 2016

Abstract: Water Quality Index was applied to assess suitability of groundwater quality for drinking purposes in Durresi-Kavaja Basin, Rrogozhina Aquifer, Albania. The availability of good quality water is a necessary feature for preventing diseases and improving quality of life. Durresi-Kavaja Region experienced recently a rapid urbanization that was accompanied by the enormous increase for drinking water demand which could be provided by further using groundwater. Thirty nine water samples were collected from Mars to June 2015, to assess groundwater quality of Durresi-Kavaja Basin. Eleven chemical parameters have been considered for calculating the WQI like: pH, general hardness (GH), calcium, magnesium, alkaline cations, iron, bicarbonate, chloride, nitrate, sulphate, and total dissolved solids (TDS). The computed WQI shows that 23% of water sample falls in excellent category, 72% in good water category and 5% poor water category. Water from Durresi-Kavaja Basin is mostly suitable for drinking purposes up to depth 400-500m, but further action for salinity control is required.

Keywords: *Water quality index, chemical analysis, Durres-Kavaja basin*

Introduction

The Region of Durresi-Kavaja (Central Albania) has recently lived a rapid and significant demographic increase followed by a respective increase of water demand. One source for water supply is groundwater related with water-bearing conglomerate and sandstone intercalations of Rrogozhina aquifer. The assessment of groundwater quality status is important for socio-economic development of this highly inhabited region of the country. The determination of groundwater quality for human consumption is also important for the well-being of the ever increasing population. Good quality water will ensure the sustainability of socio-economic development of the region. WQI (Water Quality Index), a technique of rating water quality, is an effective tool to assess spatial and temporal changes in ground water quality and communicate information on the quality of water to the concerned citizens and policy makers (Mishra & Patel, 2001). The WQI allows the reduction of vast amounts of data obtained from a range of physic-chemical and biological parameters to a single number in a simple reproducible manner (Tiwari & Mishra, 1985). WQI has been successfully applied to assess the quality of groundwater in the recent years because it helps the understanding of water quality issues by integrating complex data and generating a score that describes water quality status. This paper, that represents the first attempt to evaluate groundwater quality in Durresi-Kavaja Basin by using WQI, will help water users and institutions of water quality management and those of water supply to better know the situation of water quality of the basin.

Geology and Hydrogeology

The aquifer of Rrogozhina, where the Durresi-Kavaja Basin is included, extends over the western pre-Adriatic depression of Albania (Figure 1) occupying a surface of 2100 km^2. The water-bearing sandstones and conglomerates belong to Pilocene molasses formations. The lower part of the Pliocene molasses consist of a mostly clay section known as Helmesi suite, whereas the upper part is represented by the coarse grain formations of the Rrogozhina suite. The geological section of this later in the Durresi-Kavaja Basin consists mainly of conglomerates (Eftimi, 1984; Hyseni, 1995). The Quaternary formations, that fill the depression of Durresi-Kavaja Basin, consist of clay, sandy clay, silt, silty sand, sand, gravel and pebbles.

From the hydrogeological point of view it is a multilayered aquifer that occurs under typically artesian conditions. The groundwater shows variable geochemical composition due to different mineralogical composition of its medium, vast extension of the aquifer, variable geological and

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hydrogeological features, relationships with boundary aquifers and seawater, relations of the tested groundwater with respect to recharge and discharge zone and possibly the depth of wells (Eftimi 1984; Beqiraj et al., 2006). The above mainly magmatic composition of sandstones and conglomerates is also responsible for the high content of iron in the groundwater of this aquifer which occurs as Fe2+ due to the lack of O_2 (Gruett, 1993; Postma, 1987). Iron content is higher in sandstone (Figure 4) related groundwater where the silt fraction is mainly composed by iron-bearing minerals such as magnetite, epidote, granate, sphene, amphibole and pyroxene. In general, the wells are drilled down to 250m. The general mineralization and general hardness of groundwater pumped from the above production section range from 500 to 800 mg/L and from 11 to 25ºdH, respectively. At the pH's commonly encountered in groundwater (pH=7.0-8.5), HCO3- is the dominant carbonate species present. In general, up to depth 250 m, all the hydrochemical parameters of the groundwater fit the Albanian and EU limits for the potable water. In some cases, NH_4^+, SO_4^{2-}, C^- *etc*, are found in concentrations higher than the limits of drinking water. In the diagram (not shown) of Total Dissolved Solids (TDS) versus well depth (H) was found that groundwater can maintain TDS values less that 1.0 mg/L up to a depth that ranges from 400 to 500m according to the well position with respect to recharge and discharge zone (Beqiraj *et al.*, 2006).

Material and methods

Groundwater samples were collected from 39 locations during Mars - June April 2015 and the groundwater was put in acid washed plastic container to avoid unpredictable changes in characteristics of water. The locations of the collected sample were selected based on the local variability in landform, geology, soil, geography and other management practices. Each of the groundwater samples was analyzed for 11 parameters such as pH, Total Dissolved Solids (TDS), general hardness (TH), bicarbonate, chloride, sulphate, nitrate, calcium, magnesium, iron and alkaline cations. Details of sampling locations along with their latitude and longitude are presented in Table 1.

Groundwater chemistry has been utilized as a tool to assess water quality for drinking purposes Calculation of water quality index (WQI) is an important technique for demarcating groundwater quality and its suitability for drinking purposes (Tiwari et al., 1985). WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption (Mitra, 1998). The Albanian Standards for drinking purposes, which fit with those of EU, are considered for the calculation of WQI.

Table 1: Sampling location

No. Well	**Coordinates**		**No. Well**	**Coordinates**	
	X	**Y**		**X**	**Y**
1	4591250	4374250	21	4556490	4382780
2	4577150	4371425	22	4556120	4382920
3	4570670	4376210	23	4555570	4382980
4	4591300	4375200	24	4549750	4373150
5	4585850	4369950	25	4549750	4373171
6	4581050	4372425	26	4549225	4373300
7	4581250	4373650	27	4547550	4374300
8	4584100	4370675	28	4548301	4388072
9	4581172	4372759	29	4548549	4388625
10	4557805	4381767	30	4547624	4438923
11	4554308	4383551	31	4562175	4378850
12	4557325	4375475	32	4560240	4380370
13	4552817	4380542	33	4560400	4380265
14	4553772	4380843	34	4563185	4378625
15	4553453	4382912	35	4562332	4377627
16	4554795	4383110	36	4563506	4376760
17	4556075	4382900	37	4561500	4374600
18	4556775	4382375	38	4562250	4378600
19	4556120	4382930	39	4555260	4385526
20	4556490	4382865			

Firstly, each of 11 parameters has been assigned a weight (w) as indicated in Table 2, according to its relative importance in the overall quality of water for drinking purposes. The maximum weight of 5 has been assigned to General Hardness due to its importance in water quality assessment. Magnesium is given the minimum weight of 1 which indicates that, it may not be deleterious.

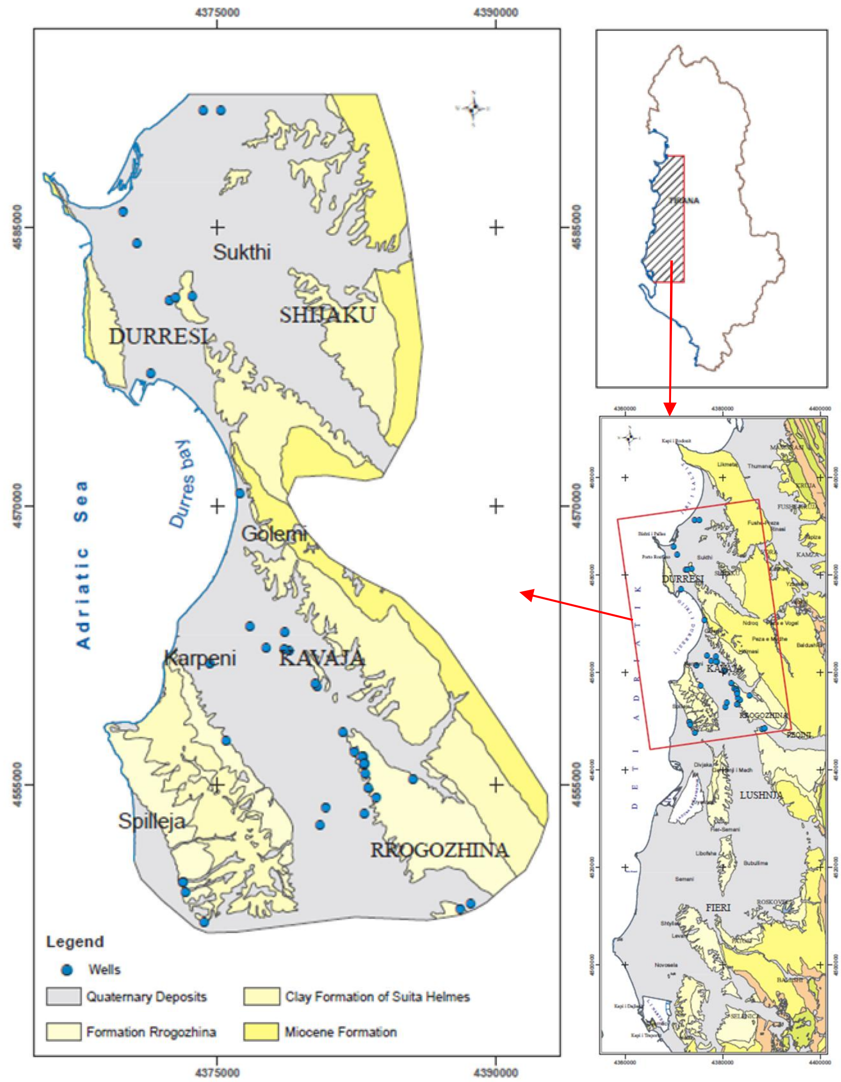

Figure 1. Geological map of the Durresi – Kavaja Basin

Then, the relative weight (W) is computed using a weighted arithmetic index method given below (Brown *et al*., 1970; Horton, 1965; Tiwari & Manzoor, 1988) in the following equation:

$$W_i = \frac{w_1}{\sum_{i=1}^{n} wi} \qquad (1)$$

Where Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters. Calculated relative weight (Wi) values of each parameter are also given in Table 2. Finally, a quality rating scale (Q) for each parameter is assigned by dividing its concentration in each water sample by its respective Albanian Standard according and then multiplied by 100.

$$qi = (Ci / Sa) \times 100 \qquad (2)$$

where, qi is the quality rating, Ci is the concentration of each parameter in each water sample in mg/L and Sa is the Albanian drinking water standard for each chemical parameter in mg/L. For computing

the WQI the SIi is first determine for each parameter, which is then used to determine the WQI as indicated by the following equation $Sl_i=W_i*q_i$.
Finally, the overall water quality index (WQI) was calculated by adding together each sub index values of each groundwater samples as follows: $WQI = \sum Sl_i$

Table 2. Albanian Standard (S_a) and relative weight (w_i) for the chemical parameters

Chemical parameters	*Units*	*Albania Standard (S_a)*	*Weight*	*(w_i)*
GH	°dH	20	5	0.1429
Na+K	mg/L	200	2	0.0571
Ca	mg/L	200	2	0.0286
Mg	mg/L	50	4	0.1143
Fe	mg/L	0.3	2	0.1143
HCO3	mg/L	450	3	0.0857
SO4	mg/L	250	1	0.0286
Cl	mg/L	250	3	0.0857
TDS	mg/L	1000	3	0.0857
pH	mg/L	7.0-8.0	4	0.1143
NO3	mg/L	50	4	0.1429
	Total		**34**	**1.000**

Results and Discussion

pH: The permissible limit of pH in drinking water is within 7.0 – 8.0 according to Albanian Standard. The value of pH in groundwater samples of the study area ranges between 7.3 and 8.8, mostly falling within the permissible range (Figure 2). Waters from samples no. 3, 7, 8, 10, 20, 26, 28, 30, 31, 32, 33, 34, 35 and 36 the pH is slightly alkaline having values over the upper permitted limit value (8.0).

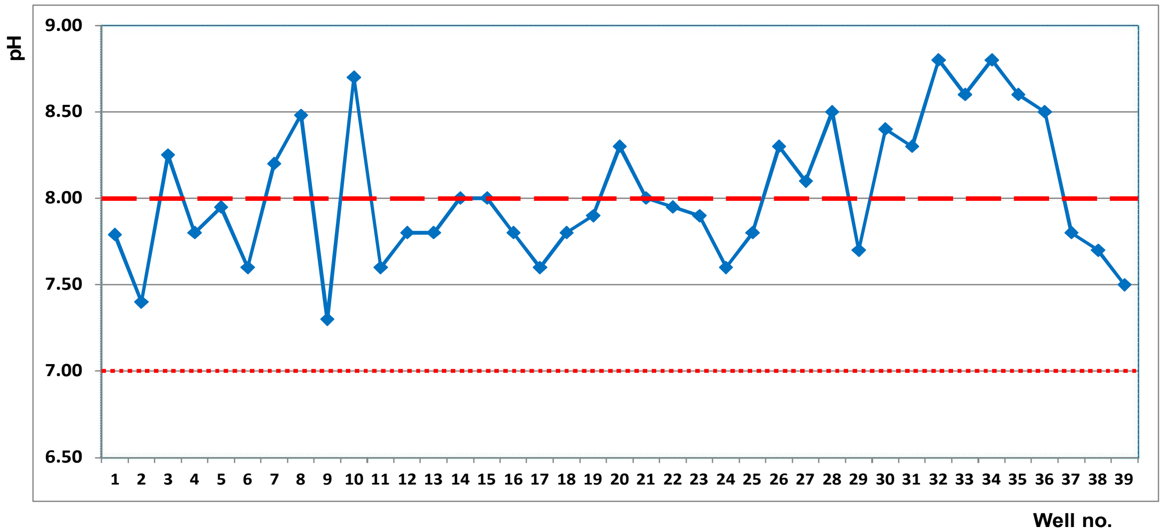

Figure 2. Variation of pH values in the Durresi-Kavaja Basin groundwater (red dot line and dash line show permissible low and high Albanian Standard limits of pH, respectively)

Total dissolved solids (TDS)*:*The value of TDS in ground water samples from the study area ranges from 471 to 1796 mg/L, having an average value of 749.39 mg/L. The higher values belong to groundwater towards the discharge zone, i.e. toward the coastal zone. As it can be seen in the Figure 3, all the water samples (except sample 27) have TDS values below the Albanian Standard value (1000 mg/L) and most of them have TDS values less than 700 mg/L, being characterized as good waters.

General hardness (GH): The limit of GH in drinking water must be within 10 – 15 according to Albanian Standard (Table 1). Most of water samples from the study area have values of GH higher than the upper permitted limit of Albanian Standard (Figure 4) as shown by the average value of GH=19.21 °dH. These values of GH confirm that groundwater of Rrogozhina aquifer within the territory of Durresi-Kavaja Basin is hard to very hard. This is related with both carbonate cement of conglomerate and long-time residence of groundwater due to low permeability of the aquifer medium.

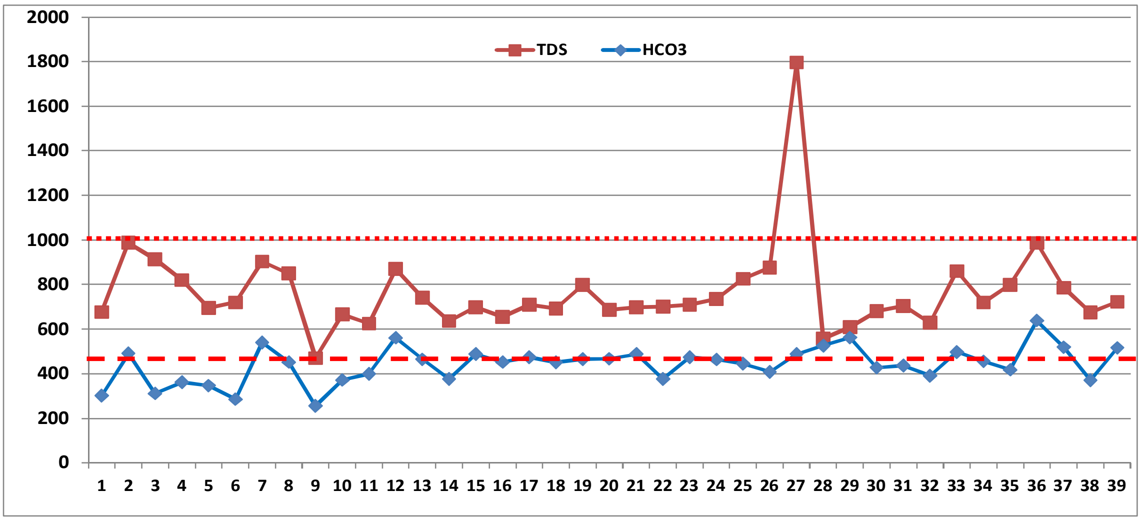

Figure 3. Variation of TDS and HCO_3^- values in the Durresi-Kavaja Basin groundwater (red dot line and dash line show the Albanian Standard permissible value for TDS and HCO_3^-, respectively)

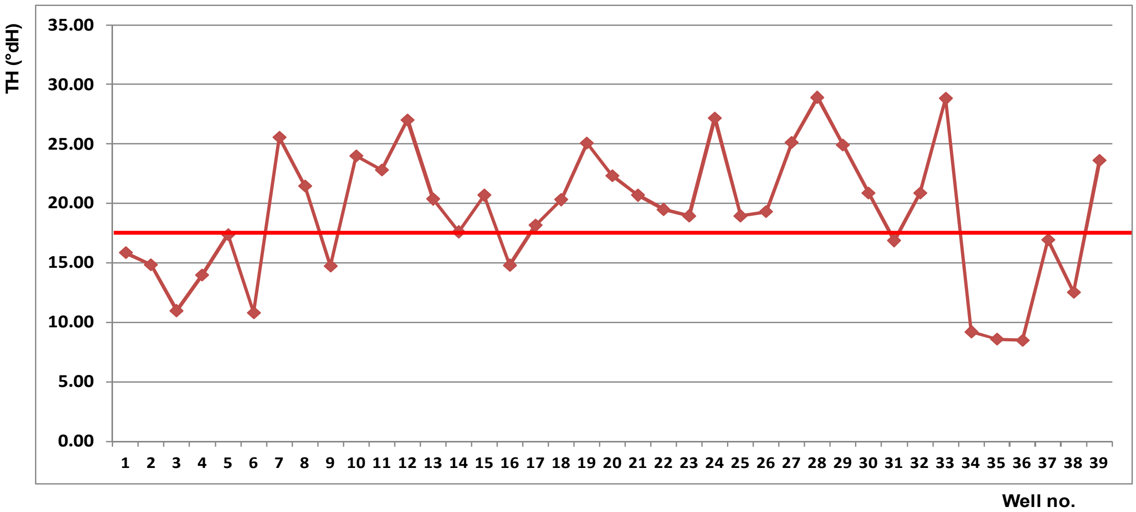

Figure 4. Variation of GH values in the Durresi-Kavaja Basin groundwater (red line shows the Albanian Standard permissible value of pH)

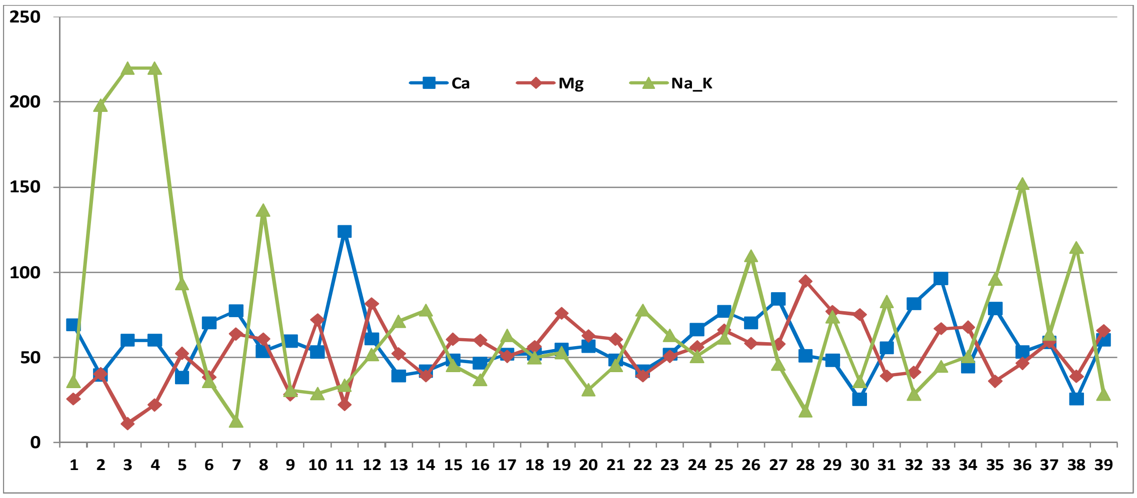

Figure 5. Variation of Mg, Ca and alkaline cation content in the Durresi-Kavaja Basin

Cations concentrations

Calcium: The content of Ca^{2+} in groundwater samples of the study area ranges between 25.5- 124 mg/L. As it could be seen in Fig. 5, most of sampled groundwater falls below the upper permitted limit of Albanian Standard (200 mg/L) for drinking water. Calcium is a major constituent of various rock types, especially of carbonates, and represents one of cations that causes hardness in water. Calcium is also essential constituent of different human body organs. The content of Ca in the studied groundwater fits very well with the above requirements.

Magnesium: The maximum permissible limit of magnesium content is 50 mg/l according to Albanian Standard. The concentration of magnesium in the study area ranges from 11 to 94 mg/L (Figure 5) showing an average value of 53.08 mg/l. The sources of magnesium in groundwater is the almost magmatic and carbonate composition of the aquifer medium which consists of Mg-rich minerals.

Anions concentration

Sulphate: The sulphate concentrations were found to be in the range of 6.6 to 88.40 mg/L (Figure 6) and are clearly below the Albanian Standard value (250mg/l). Large quantities of sulphate may cause dehydration and gastrointestinal irritation. It is also known the impact of sulphate to the corrosion of distribution systems.

Chloride: The Chloride concentration in the study area ranges from 24 - 282 mg/L (Figure 6) being well within the permissible limits (250 mg/l). High chloride content may harm metallic pipes and structures as well as growing plants. Chlorides in excess gives the salty taste to water. Higher concentrations of chloride are present in groundwater of the coastal zones.

Nitrate: The nitrate concentration in the study area ranges from 2 - 39 mg/L (Figure 6), while the permissible limit of nitrate is 50 mg/l according to Albanian Standard for drinking water. The higher contents of nitrates belong to water samples taken from shallow wells where the impact of chemical fertilizers is higher. It can be toxic to certain aquatic organisms even at concentration of 100 mg/l. In excessive limits, it contributes to the illness known as methenoglobinemia in infants.

Water Quality Index (WQI): The computed WQI values for 39 wells in Durresi-Kavaja Basin watershed ranges from 43 to 103, as shown in fig. 7 and can be categorized into three types: excellent water, good water and poor water. Table 3 shows the percentage of water samples that fall under different quality categories. Thus, 23% of wells water fall in class I -excellent water, 72% falls in class II - good water and only 5% fall in class III – poor water.

Table 3. Water quality classification based on WQI value

WQI value	Class	Water quality	Percentage of studied water sample
<50	I	Excellent	23%
50-100	II	Good water	72%
100-200	III	Poor water	5%
200-300	IV	Very poor water	0%
>300	V	Unsuitable water	0%

The above water quality categories derived through the application of WQI confirm recent findings of other authors (Beqiraj & Kumanova, 2010) who showed that TDS values of groundwater will be less that 1.0 mg/L up to a depth 400 - 500 m. The excellent water quality belongs to groundwater that was sampled from the wells located near the recharge zone, that is, along the hill slopes where the water-bearing conglomerate and sandstone outcrop. Towards the valley, the depth of the groundwater flow increases and its residence time is longer, thus resulting in the respective increase of values of chemical parameters and, in particular, of TDS. The highest values of TDS and general hardness are found in the groundwater from wells located near the discharge zone which are characterized as poor water according to WQI.

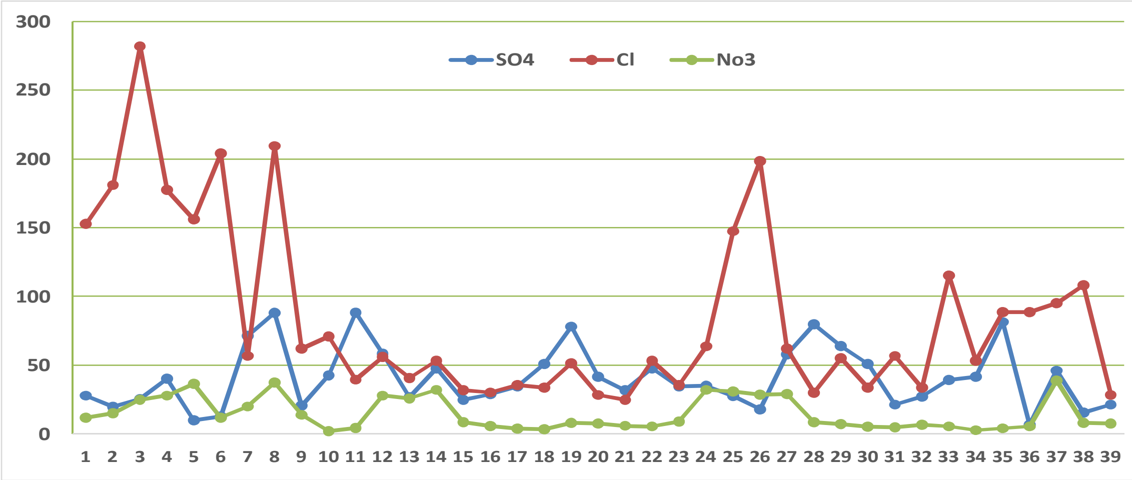

Figure 6. Variation of Mg, Ca and alkaline content in the Durresi-Kavaja Basin groundwater Values of Anions for all studied samples

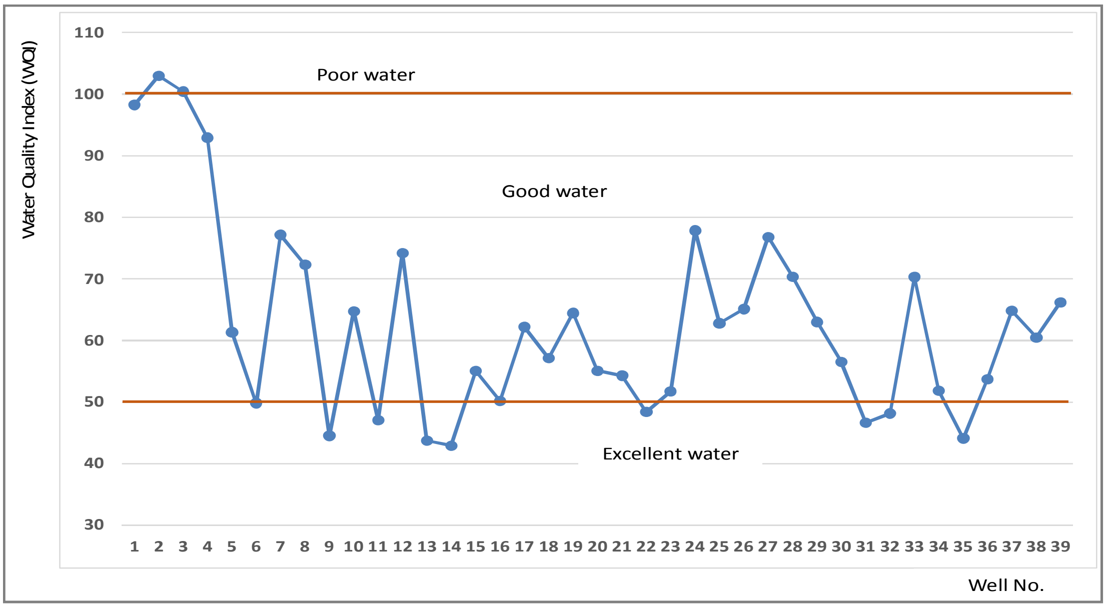

Figure 7. Variation of WQI values in the studied water samples

Conclusions

The different mineralogical composition of the medium along with vast extension of the aquifer and its relationships with boundary aquifers and seawater have conditioned variable geochemical composition of the groundwater. Up to depth 400 - 500m from the surface, the value of total dissolved solids of groundwater is generally less than 1.0 g/L. Based on the WQI methodology, the groundwater of Durres-Kavaja basin falls in three classes: class I - excellent water, class II - good water and class III – poor water which represent 23%, 72% and 5% of the sampled water wells within the study basin, respectively. The excellent water quality belongs to groundwater from the wells located near the recharge zone, while the poor water comes mostly from the deep wells near the discharge zone. Such a scenery of the water quality from the Durresi-Kavaja basin, shows that it may represent an interesting source of potable water for the needs of the community in this region.

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