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# Water Quality Assessment of the Kopal River (IRAN)

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## ABSTRACT

The Kopal River in the Khozestan province, IRAN, is the most important river on the plain and water capability for agriculture in this plain was provided from this river. It is planning to construct a reservoir on the river in the Haftgel area in order to supply the agriculture and drinking consumptions in that region. Therefore, the study on the water quality of this river is very important role in take any decision. In this paper the water quality parameters such as $HCO3^{-}$ ‘$SO4^{-2}$ ‘$CL^{-1}$ ‘$K^{+}$ ‘$Na^{+}$ ‘$Mg^{+2}$ ‘$Ca^{+2}$ and $SO4^{-2}$ are evaluated base on the sampled data which taken in the Hydrometric station in the period from 1981-2001. In general, 162 series data are used. For assessment of the water the Wilcox diagram are used. Base on this criterion, the water of Kopal River has high harness and it is not suitable for dinking uses. Also the water is classified as C4S2, C4S3 and C4S4; therefore it is not suitable for the irrigation consumptions.

**Keywords:** Water Quality, Irrigation, Agriculture, Kopal River

## INTRODUCTION

Intensifying water scarcity is now a global phenomenon. The water resources of many regions of the world are insufficient to meet the demands for food, municipal and industrial uses and environmental uses. Even countries that are relatively richly endowed with water may have to address regional or temporary water scarcity. The arid and semi- arid regions of the world are experiencing the most intense water scarcity. Agriculture is the largest consumptive user of water throughout the world. The productivity of irrigated agriculture is significantly higher than the productivity of rained agriculture, particularly in arid and semi-arid regions. The consequence is that agricultural uses of water are very important in generating the food needed to serve the populations of the region. Nevertheless, the growth in competing demands means that efforts will have to be made to manage agricultural water in the most efficient ways possible (Vaux, 2007, ref: Holliday, 2007).Irrigation of agricultural lands accounted for 70% of the water used worldwide. In several developing countries, irrigation represents up to 95% of all water uses, and plays a major role in food production and food security. Future agricultural development strategies of most of these countries depend on the possibility to maintain, improve and expand irrigated agriculture. On the other hand, the increasing pressure on water resources by agriculture faces competition from other water use sectors and represents a threat to the environment (Bauder et al., 2003).

### Water Quality

The water quality used for irrigation is essential for the yield and quantity of crops, maintenance of soil productivity, and protection of the environment. For example, the physical and mechanical properties of the soil, soil structure (stability of aggregates) and permeability are very sensitive to the type of exchangeable ions present in irrigation waters. Defining background conditions of water quality is important for water and land managers in assessing the effects of human activities, such as land use, on water resources (Stoner et al., 1998). Irrigated agriculture is dependent on an adequate water supply of usable quality. Water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available. This situation is now changing in many areas. Intensive use of nearly all good quality supplies means that new irrigation projects and old projects seeking new or supplemental supplies must rely on lower quality and less desirable sources. To avoid problems when using these poor quality water supplies, there must be sound planning to ensure that the quality of water available is put to the best use. Conceptually, water quality refers to the characteristics of a water supply that will influence its suitability for a specific use, i.e. how well the quality meets the needs of the user. Quality is defined by certain physical, chemical and biological characteristics. Even a personal preference such as taste is a simple evaluation of acceptability. For example, if two drinking waters of equally good quality are available, people may express a preference for one supply rather than the other, the better tasting water becomes the preferred supply. In irrigation water evaluation, emphasis is placed on the chemical and physical characteristics of the water and only rarely is any other factors considered important. Specific uses have different quality needs and one water supply is considered more acceptable (of better quality) if it produces better results or causes fewer problems than an alternative water supply. For example, good quality river water which can be used successfully for irrigation may, because of its sediment load, be unacceptable for municipal use without treatment to remove the sediment. Similarly, snowmelt water of excellent quality for municipal use may be too corrosive for industrial use without treatment to reduce its corrosion potential (Ayers and Westcot, 1985). There have been a number of different water quality guidelines related to irrigated agriculture. Each has been useful but none has been entirely satisfactory because of the wide variability in field conditions. Hopefully, each new set of guidelines has improved our predictive capability. The guidelines presented in this paper have relied on Wilcoks method to give more practical procedures for evaluating and managing water quality-related problems of irrigated agriculture. Irrigation water quality can best be determined by chemical laboratory analysis. The most important factors to determine the suitability of water use in agriculture are the following:

**Salinity (**EC or TDS)

**Cations and Anions (**Calcium ($Ca^{++}$), Magnesium ($Mg^{++}$), Sodium ($Na^{+}$), Carbonate ($CO^{--}_{3}$), Potassium ($K^{+}$), Chloride ($Cl^{-}$) and Sulphate ($SO_4^{--}$))

**Miscellaneous Effects (**Bicarbonate ($HCO_3$), pH and Sodium Adsorption Ratio (SAR))

**Total Dissolved Solids (TDS)**

Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates) and some small amounts of organic matter that are dissolved in water. Total dissolved solids (TDS) may be of interest for water supply and other uses. High TDS levels are undesirable for municipal and irrigation water supply. TDS in drinking-water originate from natural sources, sewage, urban run-off, industrial wastewater, and chemicals used in the water treatment process, and the nature of the piping or hardware used to convey the water, i.e., the plumbing (WHO, 2006).In general, the total dissolved solids concentration is the sum of the cations (positively charged) and anions (negatively charged) ions in the water. Therefore, the total dissolved solids test provides a qualitative measure of the amount of dissolved ions, but does not tell us the nature or ion relationships. In addition, the test does not provide us insight into the specific water quality issues, such as: elevated hardness, salty taste, or corrosiveness. Therefore, the total dissolved solids test is used as an indicator test to determine the general quality of the water (Bauder et al., 2003). Salts, salinity, electrical conductivity ($EC_w$), or total dissolved solids (TDS), these terms are all comparable and all quantify the amount of dissolved "salts" (or ions, charged particles) in a water sample. However, TDS is a direct measurement of dissolved ions and EC is an indirect measurement of ions by an electrode. (Bauder et al., 2003). For classification of the agriculture water the Wilcox (1955) method is the most important method. Base on this method it can be classified the water in five categories as following (table 1):

Table 1. General classification of water based on EC values (after Wilcox 1955)

| **Classes of water** | **Electrical Conductivity** (mmohs/ cm) |
|---|---|
| Excellent | EC<250 |
| Good | 250< EC<750 |
| Permissible[1] | 750< EC<2250 |
| Doubtful | 2250< EC<3000 |
| Unsuitable | EC>3000 |

From a practical viewpoint, the degree of hardness can be interpreted as following (Zuane, 1997):

Table 2. General classification of water based on TDS values (after Zuane 1997)

| **Classes of water** | **TDS** (mg/L) |
|---|---|
| Soft | 0-50 |
| Moderately hard | 50-150 |
| hard | 150-300 |
| Very hard | >300 |

**pH and Alkalinity**

The acidity or basicity of irrigation water is expressed as pH. Its scale is from 0 to 14. Values higher than 7 considered alkaline and values less than 7 are acid. Water pH regulates aquatic chemistry and can impact water use and habitat (Rabe and White, 1994). The normal pH range for irrigation water is from 6.5 to 8.4 (Ayers and Westcot, 1985). High PH's above 8.5 are often caused by high bicarbonate ($HCO_3^-$) and carbonate ($CO_3^{2-}$) concentrations, known as alkalinity. High carbonates cause calcium and magnesium ions to form insoluble minerals leaving sodium as the dominant ion in solution. This alkaline water could intensify sodic soil conditions (Bauder et al., 2003).

**Sodium Hazard**

Due to its effect on the soil and plant, sodium is considered to be one of the major factors governing ware quality. The EC value can also be used to predict soil structure stability in relation to irrigation water quality. The Sodium Adsorption Ratio (SAR) of irrigation water is also required for this (DeHayr et al., 2006). Wilcox (1958) submitted a diagram, illustrating the relation between the quality of irrigation water and the $Na^{+}:(Ca^{2+}+Mg^{2+})$ ratio. Based on this criterion the irrigation water can be classified in five groups as Low, Medium, High and Very high sodium water.

Table 3. General classification of water based on percent Sodium (after Wilcox 1955)

| **Classes of water** | **Percent Sodium** |
|---|---|
| Excellent | <20 |
| Good | 20-40 |
| Permissible | 40-60 |
| Doubtful | 60-80 |
| Unsuitable | >80 |

Also the sodium hazard can be expressed based on the sodium adsorption ratio (SAR) by the US Salinity Laboratory. This index quantifies the proportion of sodium ($Na^{+}$) to calcium ($Ca^{++}$) and magnesium ($Mg^{++}$) ions in a sample.

$$SAR = \frac{Na^{+}_{meq/L}}{\sqrt{\frac{(Ca^{++}_{meq/L}) + (Mg^{++}_{meq/L})}{2}}} \quad (1)$$

Calcium will flocculate (hold together), while sodium disperses (pushes apart) soil particles. This dispersed soil will readily crust and have water infiltration and permeability problems. General classifications of irrigation water based upon SAR values are presented in Table 3.

Table 4- General classification of water sodium hazard based on SAR values (after Bauder et al., 2003).

| SAR values | Sodium hazard of water | Comments |
|---|---|---|
| 1-9 | Low | Use on sodium sensitive crops must be cautioned. |
| 10-17 | Medium | Amendments (such as gypsum) and leaching needed. |
| 18-25 | High | Generally unsuitable for continuous use. |
| ≥26 | Very High | Generally unsuitable for use. |

High concentrations of sodium in irrigation water can result in the degradation of well-structured soils. This will limit aeration and soil permeability to water, leading to reduced crop growth (DeHayr et al., 2006 ). Sodium in irrigation water can also cause toxicity problems for some crops, especially when sprinkler applied (Bauder et al., 2003).

**Chloride**

Since the chloride ion has no effect on the physical properties of a soil and is not adsorbed on the soil complex it has generally not been included in modern classification systems, it appears, however, as a factor in some regional water classifications. Although chloride is essential to plants in very low amounts, it can cause toxicity to sensitive crops at high concentrations (Table 4). Like sodium, high chloride concentrations cause more problems when applied with sprinkler irrigation. Leaf burn under sprinkler from both sodium and chloride can be reduced by night time irrigation or application on cool, cloudy days. Drop nozzles and drag hoses are also recommended when applying any saline irrigation water through a sprinkler system to avoid direct contact with leaf surfaces (Mass, 1990).

Table 5- Chloride classification of irrigation water (after Bauder et al., 2003)

| Chloride (ppm) | Effect on Crops |
|---|---|
| Below 70 | Generally safe for all plants |
| 70-140 | Sensitive plants show injury |
| 141-350 | Moderately tolerant plants show injury |
| Above 350 | Can cause severe problems |

Usual range of Chloride in irrigation water is Chloride 0-30 me/l (Ayers and Westcot, 1985)

**Sulfate ($SO_4^{2-}$)**

Usually, sulfate ion exists in the total of natural water. The sulfates of sodium, magnesium, potassium are easily soluble in the water, but sulfate calcium has low capability. The presence of sulfate in the soil is rarely a problem, except at very high concentrations where high sulfate may interfere with uptake of other nutrients. As with boron, sulfate in irrigation water has fertility benefits (Bauder et al., 2003).

**Calcium ($Ca^{++}$) and Magnesium ($Mg^{++}$)**

Calcium and Magnesium (Ca, Mg) are cations (positively charged ions) which are present in water. They are widely distributed in ores and minerals. They are also very chemically active; therefore they are not found in the elemental state in nature. Calcium and Magnesium ions are of particular importance in water pollution. They may contribute to water hardness. In most cases the sum of Ca and Mg are reported in mill-equivalents/liter. Together Ca + Mg may be used to establish the relationship to total salinity and to estimate the sodium hazard (Wilkerson, 2008).

Szabolcs and Darab consider that one of the most important qualitative criteria is the Mg content of the irrigation water, calculated by formula (FAO, 1973):

$$\frac{[Mg^{++}]}{[Ca^{++}]+[Mg^{++}]}100 \qquad (2)$$

High magnesium affects the soil unfavorably; a harmful effect on soil appears when the above ration exceeds 50.

## MATERIALS and METHODS

Kondok river basin is situated in the Southern Western part of Iran. The main river originates from the slopes of mounts Haftgel and Ghalegiri. This river is a water source for the city of Haftgel in Khozestan Province. The major tributary of this river is Gazin. After 23km this river joined with the Kopal River. The river basin measures 1848 $km^2$. There is a hydrometric station on this river which constructed in the 1982. Figure 1 shows a map of the watershed. River water pollution hinders the socio-economic development of the Iran (Ye et al., 2006), discourages tourism and reaction and degrades the quality of life of local people (Najafpoor et al., 2007).

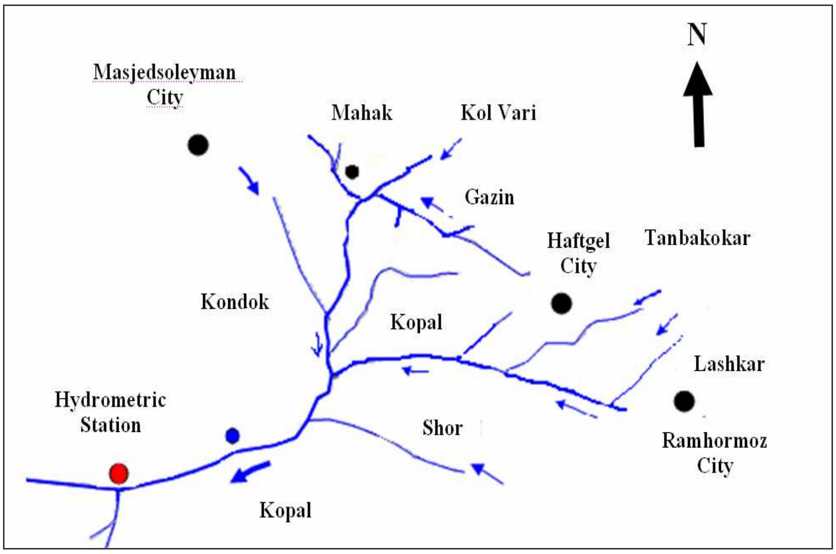


Figure 1- A schematic of the tributaries of the Kondok and Kopal River

The methodology of river water quality monitoring conducting by KWPA, covers measurements that are applied one to twelve times each year, on the hydrometric station, in the period from 1981- 2004. The KWPA staffs have been collecting water samples. Methods (sampling, handlings of samples) used for river monitoring were conformed to the international standard or equivalent national methods. As it is mentioned earlier it is planning to construct a reservoir on the river in the Haftgel area in order to supply the agriculture and drinking consumptions in that region. Therefore, the study on the water quality of this river is very important role in take any decision. The parameters which measured were PH, EC, total dissolved solids (TDS), $HCO_3^-$, $SO_4^{-2}$ ،$CL^-$ ،$K^+$ ،$Na^+$ ،$Mg^{++}$ ،$Ca^{++}$ and $SO4^{-2}$ and S.A.R. For this purpose the sample data which collected from the hydrometric station from 1981 to 2001 are used. Improvement of the river water quality management is still needed in Iran, for a better quality of life of its inhabitants and to line up with the WHO environmental standards. Table 7 shows the statistical parameters of the measured water quality of the Kopal River at Hydrometric station.

Table 6 – The statistical parameters of the measured water quality of the Kopal River at Hydrometric station

| Parameter | T.D.S mg/lit | E.C.*10^6 25 c° mmhos/cm | PH | + Na % | S.A.R - | + K (meq/lit) | Na (meq/lit) | +2 Mg (meq/lit) | +2 Ca (meq/lit) | -2 So4 (meq/lit) | - Cl (meq/lit) | - Hco3 (meq/lit) | -2 Co3 (meq/lit) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum | 9728.0 | 14520.0 | 8.5 | 55.6 | 14.9 | 0.6 | 80.0 | 33.3 | 41.5 | 68.0 | 78.0 | 4.0 | 0.6 |
| Mean | 4801.5 | 6788.8 | 8.0 | 45.1 | 7.8 | 0.2 | 36.3 | 15.3 | 27.1 | 39.8 | 36.5 | 2.5 | 0.0 |
| Minimum | 1712.0 | 2265.0 | 7.3 | 29.0 | 1.0 | 0.0 | 3.8 | 1.8 | 14.5 | 4.8 | 3.5 | 0.9 | 0.0 |
| Standard Deviation | 1234.6 | 1919.2 | 0.2 | 8.5 | 2.3 | 0.1 | 13.3 | 5.8 | 4.0 | 9.1 | 13.0 | 0.6 | 0.1 |
| Variation %) | 25.7 | 28.3 | 2.9 | 18.8 | 29.9 | 45.0 | 36.7 | 37.7 | 14.6 | 22.9 | 35.6 | 24.6 | 561.7 |

## RESULTS and DISCUSSION

### Water Quality Variation based on TDS and EC.

To know the variation of Water Quality from 1981-2001, 162 collected data at the Kopal River at Hydrometric station have been used for analysis. Based on the measured values of the TDS (table 7), the minimum and maximum value of the TDS are 1712 and 9728. As the TDS values are more than 300, from the drinking view the degree of hardness is very hard. Also the minimum and maximum value of the EC are 2265 and 14520. As the EC values are more than 2250, based on the Wilcox method the water of this river classified in the Doubtful and Unsuitable category.

A line graph trend line has been plotted for TDS and EC values versus discharge of the river as shown in following figures 2 and 3. As it observed from these figures the decreasing of the discharge would caused the increasing of TDS and EC. As at the discharge less than 0.1m$^3$/s, the amount of TDS and EC would be more than 6500 mg/L and 9000 micro mhos/cm, respectively. In the other words, reduced flows can cause accelerated increases total dissolved solids (TDS) concentrations and EC in downstream reaches of the river.

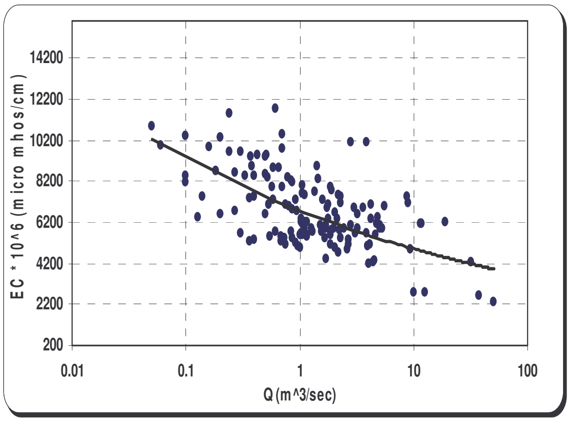


Figure 2- The variation of T.D.S versus EC of the Kopal River

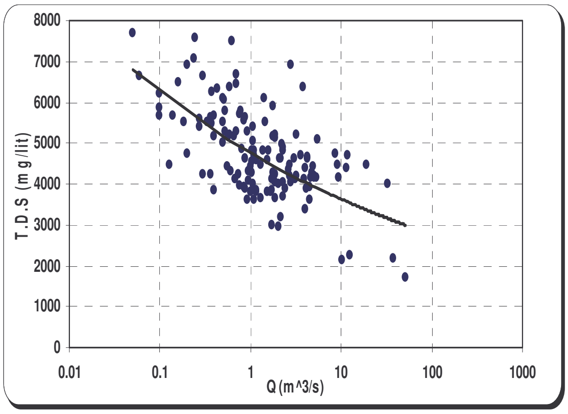


Figure 3- The variation of EC versus discharge of the Kopal River

### Sodium and Sodium Adsorption Ratio (SAR)

The measurement of the sodium of the sample data shows that the minimum and maximum values of the sodium percentage are 29 and 55.6. Base on the Wilcox method the water of this river classified in permissible category (table 2). Also the sodium hazard can be expressed based on the sodium adsorption ratio (SAR). This index quantifies the proportion of sodium ($Na^+$) to calcium ($Ca^{++}$) and magnesium ($Mg^{++}$) ions in a sample. The calculated value of the SAR shows that the minimum, mean and maximum values of this parameter are 1, 7.8 and 14.9. In comparison to the criteria of table 3 this water has low sodium hazard.

**pH**

As it is mentioned earlier the acidity of irrigation water is expressed as pH. The measured values of the PH show that the min and max values of it range 7.3 to 8.5. In other word the water of this river from the viewpoint of irrigation consumption is normal.

**Calcium ($Ca^{++}$) and Magnesium ($Mg^{++}$)**

Calcium and Magnesium (Ca, Mg) are cations which are present in water. Szabolcs and Darab(FAO, 1973) consider that one of the most important qualitative criteria is the Mg content of the irrigation water, calculated by equation 1. The calculated of this parameter show that the minimum, mean and maximum percentage values of this parameter are 11, 36 and 44. As the maximum value of this parameter is below 50, therefore it has not harmful effect on soil.

**Chloride**

As it is mentioned earlier the chloride ion has no effect on the physical properties of a soil and is not adsorbed on the soil. Chloride is essential to plants in very low amounts; it can cause toxicity to sensitive crops at high concentrations. The measurement of chloride shows that the minimum and maximum values of the chloride are 3.5 and 78. In comparison with the criteria which mentioned in the table 5 (Bauder et al., 2003), the amount of chloride is nearly low and it is generally safe for all plants.

**Wilcox diagram**

The gathered water quality data of the Hydrometric station on the Kopal River are plotted on the Wilcox diagram (Figure 4). As it is observed from this figure the water of this river has bad condition and it is not suitable for drinking consumption.

From the view point of agriculture using the water of this river classified C4S2, C4S3 and C4S4. In other word the water of this river has the bad condition and it is not suitable for agriculture.

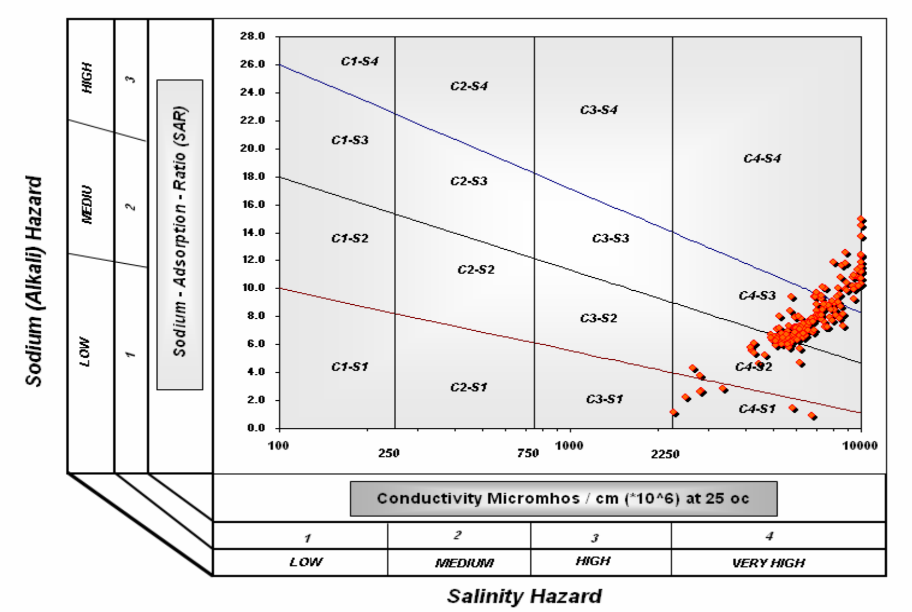


Figure 4- The Wilcox diagram of the Kopal River

## CONCLUSION

The purpose of this study was to compile and analyze the available water-quality data on Salinity (EC or TDS), Cations and Anions (Calcium, Magnesium, Sodium, Carbonate, Potassium, Chloride, Sulphate), Miscellaneous Effects (Bicarbonate, pH, Sodium Adsorption Ratio) in the Kondok River which covers 1848 $km^2$ and encompasses parts of Southern Iran, Khozestan. Our data indicates that water quality conditions in the Kopal River didn't meet the target water quality standard for drinking and agriculture using.

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