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Determination of suitability of water quality for agricultural purposes using new scoring based Randev and Puri classification

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Abstract

To determine the suitability of water for various purposes such as agriculture, domestic and drinking, different classification methods has been developed over the time. Each classification system use few parameters to determine suitability of water quality for different purposes. New scoring based Randev and Puri classification was developed to determine suitability of water quality for irrigation purposed, because it was noted that most of classification uses just one or two parameters. On the basis of one or two parameter, it is not possible to present overall estimation of water quality. In this system, water quality was classified on the basis of well-known ten classifications (total hardness, electrical conductivity, total dissolved solids, sodium absorption ratio, magnesium hazard, Kelley's ratio, soluble sodium percentage, sodium absorption ratio, Stuyfzand's classification, United Stated soil laboratory) and then score were provide to each class in different classification. Than overall scores were calculated and on the basis of these scores final class of water quality was determined.

Keywords: Assessment, Classification, Electrical conductivity, Score and Suitability, Water quality.

Introduction

Water is most ample constituent, covering more than 70% of earth's surface. It is present in many forms such as surface water, ground water, oceanic water, polar ice caps, etc. The capability of water to act as a solvent is highly significant and used in industries, agriculture and domestic works. In these practices water get worsened as it contains waste and other hazardous substances known as pollutants. Water is the key resource upon which society relies on for its life, including its health and recreation. It is also the foremost reserve upon which social and economic growth is rooted and sustained. Aquatic ecosystems must, therefore, be essentially sheltered and preserved to ensure that they hold their innate vigor and remain appropriate for domestic, industrial, agricultural and recreational uses for present and future generations (Aweng *et al.*, 2011).

Rivers and streams play vital role in advancement of the mankind. Since time immortal, humans have been relishing the services provided by rivers and streams and has reformed the nature of these by controlling their flow, over-exploiting their living and non-living assets and above all by using them for disposal of wastes. Such taming and exploitation of reverine resources have often led to serious decline in water quality impairing their use for agriculture, drinking, recreational and other purposes and causing serious implications on human health and environment.

Agriculture sector is the main consumer of ground water and in agriculture based regions, if not used sustainably water level goes deep down hundreds of feet. Due to mishandling not only the superiority of water but it quantity is also affected. Thus, a significant source of fresh water is lost as deterioration of ground water cannot be easily reversed.

The suitability of water for any use has to fulfill various physical, chemical and microbiological criteria. (Apello and Postma, 1993). Water quality, which is influenced by numerous natural courses and anthropogenic actions, is worldwide worsening and presently an issue of research (Mishra *et al*., 2009).Agricultural harvests are also connected with water quality of river as it is used for irrigation. After green revolution, consumption of pesticides and fertilizers has reached at alarming level. These chemicals ultimately find their way to rivers and other water bodies.

Materials and Methods

An attempt to assess suitability of water for irrigation purposes on the basis of total hardness, electrical conductivity, total dissolved solids, sodium absorption ratio, magnesium hazard, Kelley's ratio, soluble sodium percentage, sodium absorption ratio, Stuyfzand's classification, United States soil laboratory classification was undertaken. The quality was ranked giving numerical numbers (1 to 5). The highest number (5) was given to best quality character and minimum number (1) to poorest quality character.

1. Water quality based on Hardness

Based on the quantitative measurement of hardness, water was classified using chart given by Sawyer et al. (1967), which was further ranked as presented in Table 1.

Table 1: Water quality based on hardness (Sawyer *et al*., 1967)

Total hardness (mg/l)	Water class	Rank
0-75	Soft	5
75-150	Moderately hard	4
150-300	Hard	3
>300	Very hard	2

2. Water quality based on electrical conductivity

Ragunath (1987) classified electrical conductivity into categories as shown in Table 2.

Table 2: Water quality based on EC as given by Ragunath (1987)

Electric conductivity (µS/cm)	Water class	Rank
0 – 250	Excellent	5
251 – 750	Good	4
751 – 2000	Permissible	3
2001 – 3000	Doubtful	2
Above 3000	Unsuitable	1

3. Salinity hazard

Salinity hazard is directly linked to the extent of salts present in the water. Classification chart for quality of water based on salinity hazard as given by U.S. salinity laboratory 1954 was used and weightage was given for further ranking it (Table 3).

Table 3: Water quality based on salinity hazard

EC (µS/cm)	Water class code	Water Class	Usage	Rank
0-250	C1	Low	Can be used for irrigation on most crops in most soils with slight possibility that soil salinity will develop.	5
251-750	C2	Medium	Can be used if a modest extent of leaching occurs.	4
751-2250	C3	High	Cannot be used on soils with limited drainage.	3
Above 2250	C4	Very High	Not suitable for irrigation under regular situations.	2

4. Sodium absorption ratio

Sodium hazard is typically expressed as sodium absorption ratio (SAR). Sodium adsorption ratio indicates the degree to which water tends to enter into cation-exchange reactions. This index quantifies the proportion of sodium to calcium and magnesium ions in a sample. Calcium will flocculate, while sodium disperses soil particles. This dispersed soil becomes crust and produces water infiltration and permeability problems. SAR was calculated using formula given by Karanth (1987):

$$\mathrm{SAR} = \frac{Na^{+}}{\sqrt{(\mathrm{Ca}^{+} + \mathrm{Mg}^{+})/2}}$$

SAR values were further used in categorizations of water given by Ragunath (1987) and rank was given to each water class (Table. 4).

Table 4: Classification of water based upon SAR values

SAR	Water class code	Water Class	Usage	Rank
0-10	S1	Excellent	Can be used for irrigation on almost all soils with slight risk of emerging damaging level of sodium.	5
11-18	S2	Good	May cause an alkalinity problem in fine textured soils under low leaching conditions. It can be used on coarse textured soils with good penetrability.	4
19-26	S3	Doubtful	May produce an alkaline problem. This water requires special soil management such as good drainage, heavy leaching and possibly the use of chemical amendments such as gypsum.	3
Above 26	S4	Unsuitable	Usually unacceptable for irrigation purpose.	2

5. USSL classification

To study the suitability of water the values of EC and SAR were compared. It gives results to understand the level of salinity and alkali hazards. Groupings of water class based upon USSL are presented in Table 5 (U.S. Salinity Laboratory 1954) and further ranking was given to water classes.

Table 5: USSL Classification for irrigation water class

USSL Classification	Water Class	Rank
C1-S1 C2-S1 C3-S1 C4-S1	Good	5
C1-S2 C2-S2 C3-S2 C4-S2	Moderate	4
C1-S3 C2-S3 C3-S3 C4-S3	Bad	3
C1-S4 C2-S4 C3-S4 C4-S4	Very Bad	2

6. Soluble sodium percentage (SSP)

Wilcox (1955) suggested categorization of water on the basis of soluble sodium percentage (SSP). Groupings of water based upon SSP and weightage given to water class are shown in Table 6. Following equation was used to calculate SSP value.

$$SSP = \frac{(Na^{+} + K^{+})}{Ca^{+} + Mg^{+} + Na^{+} + K^{+}} \times 100$$

Table 7: Water quality based on SSP

SSP	Water Class	Rank
0-20	Excellent	5
21-40	Good	4
41-60	Permissible	3
61-80	Doubtful	2
Above 80	Unsuitable	1

7. Kelley's Ratio

Usability of water for irrigation purpose depends upon ratio of different ions present. Kelley *et al*. (1940) suggested that the sodium problem in water could be conveniently worked out on the basis of the values of Kelley's ratio. Classifications of irrigation water based upon Kelley's ratio and ranking given to each water class is shown in Table 7. Ratio was calculated using formula given below.

$$Kelley's\ ratio = \frac{Na^{+}}{Ca^{+} + Mg^{+}}$$

Table 7: Water quality based on Kelley's Ratio

Kelley's Ratio	Water Class	Rank
0-1	Suitable	5
1-2	Marginal	4
Above 2	Unsuitable	3

8. Magnesium Hazard ratio

Paliwal (1972) suggested ratio equation as an index of magnesium hazards to determine the suitability of water. Table 8 shows the categorization of water class based on magnesium hazard. Following equation was used to calculate magnesium hazard:

$$Mg\ hazard = \frac{Mg^{+} \times 100}{Ca^{+} + Mg^{+} + Na^{+} + K^{+}}$$

Table 8: Water quality based on Magnesium hazard

Magnesium Hazard (%)	Water Class	Rank
0-50	Suitable	5
51-65	Marginal	4
Above 65	Unsuitable	3

9. Stuyfzand's classification

Stuyfzand (1989) proposed the classification of water based on chloride ion concentration. Stuyfsand's classification and weightage given for ranking is presented in Table 9.

Table 9: Stuyfzand's Classification of water

Stuyfzand's Classification	Code	Chloride (mg/l)	Rank
Very olingohaline	G	< 5	5
Oligohaline	g	5-30	4
Fresh	F	30-150	3
Fresh-Brackish	f	150-300	2
Brackish	B	Above 300	1

10. Water quality based on total dissolved solids

Total dissolved solids (TDS) is a measure of the contents of all inorganic and organic substances contained in a liquid in molecular, ionized or microgranular (colloidal sol) suspended form. Catroll (1962) stated that to determine the suitability of groundwater for any purpose, it is essential to classify the groundwater depending upon their hydro chemical properties based on their total dissolved solids present. Catroll gave classification of water and which is presented in Table 10 along with ranking.

Table 10: Classification of water based on TDS

TDS (mg/l)	Nature of water	Rank
0-1000	Fresh water	5
1001-10000	Brackish water	4
10001-100000	Saline water	3
Above 100000	Brine water	2

Results

Randev and Puri Classification

Quality of water based on different classifications was given score. Highest score of 5 between different sites was given to a water class which is regarded as best. This way scoring was done between 1 to 5. The lowest score of 1 was given to water class which is worst. These scores of different classifications were than summed up for a site. Based upon the total scores of a site they were further categorized following the given below classification as per table 11.

Table 11: Water quality based on scoring

Total score	Categorization / Utility
50	Excellent
46-49	Very good
41-45	Good
36-40	Marginal
31-35	Poor
26-30	Very poor
25>	Very very poor

Conclusion

The physical and chemical parameters of surface and ground water play a substantial role in classifying and evaluating the water quality. There are various classifications and indexes prepared by water scientists all around the world. But, it was observed that most of these classification were based on single parameters such as classification on the basis of TDS, EC, etc. However, better results could be obtained from a Randev and Puri classification that used results of multiple classifications. Ranking was given numerically where the highest number (5) is given if the quality is excellent and to lesser degree of quality the rank number decreased. Results of various physico-chemical parameters were used to calculate and classify water quality on the basis of ranking of inputs such as sodium absorption ration, magnesium hazard ratio, Kelly's ratio, soluble sodium ratio, sodium / alkalinity hazard, Stuyfzand's classification, United States soil laboratory classification, classification of water on the basis of total hardness, electrical conductivity and total dissolved solids.

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