World Journal of Agricultural Research, 2015, Vol. 3, No. 3, 94-101
Available online at http://pubs.sciepub.com/wjar/3/3/1

DOI:10.12691/wjar-3-3-1

Evaluation of Permeability of Lake Mansar Waters for Irrigation Purposes

S.M. Zuber*

Department of Zoology, Government Degree College (Boys) Anantnag, Kashmir, J&K, India
*Corresponding author: zubairhuma@gmail.com

Received April 03, 2015; Revised April 14, 2015; Accepted April 20, 2015

Abstract Lake Mansar is a famous tourist destination in the suburbs of Jammu which is receiving on an average 5 lac tourists every year. Subsequently a number of structures like 11 Government offices, JKTDC Cafeteria, Tea Stalls, Dhabas, Grocery shops, Bathing ghats, boating points, cremation ground, wildlife park, Dak Bungalows etc have been erected in its catchment area which have exerted their deleterious effects on the ecology of the lake. The various parameters estimated for the present study revealed that conductivity values were below 250 µmhos, TDS values were less than 500mg/l, SAR values less than 10meq/l, RSC values between 1.159 meq/l to 2.379 meq/l, SSP values between 21.110meq/l to 44.877meq/l and DPI varying between 38.006 to 81.507 which indicates that the water of Lake Mansar is best suited for irrigation purposes as it belongs to Class II category as per DPI chart.

Keywords: *conductivity, total dissolved solids, SAR, RSC, SSP, DPI, water quality, lake mansar*

Cite This Article: S.M. Zuber, "Evaluation of Permeability of Lake Mansar Waters for Irrigation Purposes." *World Journal of Agricultural Research*, vol. 3, no. 3 (2015): 94-101. doi: 10.12691/wjar-3-3-1.

1. Introduction

In agricultural practices, water is an important input for the growth of plants. This input is the basis for planning an intensive system of agricultural exploitation with sustainable characteristics (Castellanos *et al.,* 2002). Though in temperate and tropical areas, plant growth is reinforced by soil water which is continuously replenished with natural rainfall yet in arid and semi-arid climates, irrigation is desired to maintain soil water at an optimum level to get higher yield. But the quality of water whether surface or ground water varies with lithology, environment, concentration of salts in rocks etc. Moreover, irrespective of its source water contains soluble salts and impurities, which might render it ideal for domestic purposes but not for agricultural practices.

Although irrigation is useful for sustaining agricultural production yet it is imperative that only good quality water be used (Singh, 2000) as it plays an important role in the management of irrigation and leaching fraction (Ayers and Westcot, 1994). But Kirda (1977) held the notion that water quality is not the only criterion to assess the suitability of irrigation. As a matter of fact, it is worthwhile to mention that water quality is an important criterion as water used in irrigation influences the nature and permeability of soil besides the fertility. In fact, the suitability of water for irrigation depends on the water quality characteristics that ensure maximum yield under good soil and water management practices (NIH, 1998). But the quality characteristics of irrigation water depends upon the water soluble constituents like calcium, magnesium, sodium, chloride, sulphate and bicarbonates apart from the catchment water balance, soil types, climate, crop tolerance and drainage characteristics (Kirda, 1977; Stevens *et al.*, 2003; Singh *et al.*, 2005; Graham *et al.*, 2006) which could affect the physical and chemical properties of the soils (Landon, 1991).

Thus irrigation water influences the crop yield by affecting soil characteristics like salinity, soil permeability, toxicity, texture etc (Kirda, 1977). So quality of irrigation water needs to be evaluated for its suitability in agriculture. Since Lake Mansar receives agricultural run-off, sewage, silt, animal dung, faecal matter, nutrients from the cremation ground along the lake shore, detergents, soaps etc from the catchment area which has deteriorated its water quality to such an extent that most of the diseases detected among its stakeholders are water borne. Moreover the water of the lake is being used for irrigation purposes. So the present investigation was carried out, so that the suitability of the water of Lake Mansar for irrigation purposes could be worked out.

2. Materials and Methods

Lake Mansar, the rural water body surrounded by steep mountain slopes of Lower Shivalik hills is located at a distance of 64kms east of Jammu city, 40km south of Udhampur town and 25kms north of Samba town. Located at $75^0 5'11.5''$to $75^0 5'12.5''$E longitude and $32^0 40'58.25''$to $32^0 40'59.25''$N latitude, the lake is sub oval in shape with total surface area of $0.53 Km^2$ and circumference of 3.02Km. Mansar Lake believed to be about ten to fifteen thousand years old (Krishnan and Prasad, 1970), is situated amidst sedimentary rocks which are represented by sand stones alternating with clay or silt stone bands of

1-2m thickness, purple shales, nodular conglomeratic shales and breccias. The lake due to its religious significance and scenic beauty is one of the most famous tourist spots of Jammu province and hence receives lakhs of tourists every year. Moreover, Lake Mansar receives sediments from the lower Shivalik formation which is prone to erosion due to geological and tectonic set up. Deforestation, construction activities and inflow from the agricultural land in the catchment area has further aggravated the situation and the lake is shrinking at an alarming rate due to high rate of siltation. Moreover the quality of the lake water has deteriorated to an alarming extent. In order to assess the ecology and henceforth the suitability of lake water for irrigation purposes, four study stations at a distance of 500-750 meters from each other along the bank (littoral zone) were carved.

The parameters such as conductivity, total dissolved solids, carbonate, bicarbonate, calcium, magnesium, sodium and potassium were estimated following ISI (1973), APHA (1975), Kudesia (1980). The parameters like SAR, RSC, SSP and DPI were calculated with the help of the formulae:

Sodium Absorption Ratio: It was calculated with the help of the formula (Todd, 1980; Raghunath, 1987).

$$\mathbf{SAR} = \frac{Na^{++}}{\sqrt{Ca + Mg/2}}.$$

Residual Sodium Carbonate: It was calculated by the formula (Todd, 1980; Raghunath, 1987).

$$\mathbf{RSC} = \left(CO_3^{2-} + HCO_3^{-}\right) - \left(Ca^{+} + Mg^{+}\right).$$

Soluble Sodium Percentage: SSP was calculated with the help of the formula (Todd, 1980; Raghunath, 1987).

$$\mathbf{SSP} = \frac{(Na + K)100}{Ca + Mg + Na + K}.$$

Doneen's Permeability Index: It was calculated with the help of the formula (Todd, 1980; Raghunath, 1987).

$$\mathbf{PI} = \frac{Na^{++} + \sqrt{HCO_3^{-}}}{Ca^{+} + Mg^{+} + Na^{+}} x100.$$

3. Results and Discussions

From agricultural point of view, chief variables to be evaluated in the classification of water quality (Aceves, 1979; Christiansen *et al.*, 1997) are:

1. the concentration of dissolved solids and salts;
2. the relative presence of sodium (Sodium Adsorption Ratio);
3. the carbonate and bicarbonate content (Residual Sodium Carbonate);
4. percentage of sodium (SSP) and
5. the concentration of other ions like chlorides.

a) Conductivity

Conductivity, a measure of the amount of dissolved salts in water, is an excellent indicator of salinity as it denotes ionic concentration which in itself depends on the thermal properties of water (Wetzel, 2001). In fresh waters, low conductivity indicates suitability for agricultural use while as in salt waters low conductivity is an indicative of freshwater inflows such as storm water run-off (Raghunath, 1987).

During the course of present investigations (Oct., 2003 to Sept., 2005), electrical conductivity on an average varied from 159.625±8.178 µmhos (June) to 239.800±23.624 µmhos (Sept.) in first year of study and from 167.250 ±6.300 µmhos (Sept) in second year of the study (Table 1) as depicted in the Figure 1.

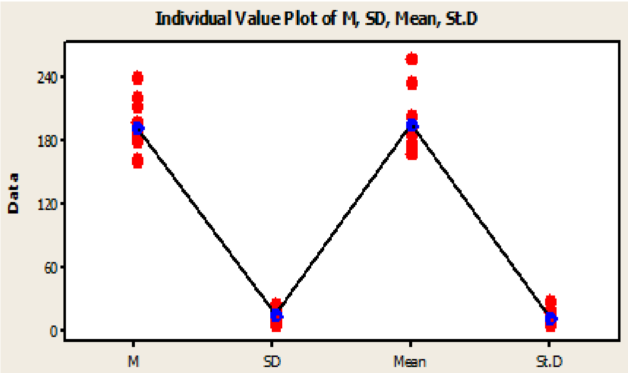


Figure 1. Range of Variation of Mean and Standard Deviation of Conductivity during the 2003-2005

Table 1. MONTHLY VARIATION IN CONDUCTIVITY (µS) ALONG THE FOUR STATIONS OF LAKE MANSAR

Year		2003 – 2004											
	Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Stations	I	164.40	178.70	182.20	184.20	205.20	184.00	181.70	180.00	160.00	184.00	210.20	225.00
	II	157.50	175.70	195.20	196.70	197.70	190.00	184.40	175.70	150.20	197.70	220.10	245.20
	III	167.4	185.70	199.10	215.20	240.20	205.10	200.80	197.70	170.10	210.70	250.20	270.80
	IV	154.00	179.27	192.50	192.50	200.80	180.20	179.27	170.20	158.20	180.60	200.10	218.20
Mean		160.825	179.842	192.250	197.150	210.975	189.825	186.542	180.900	159.625	193.250	220.150	239.800
Standard Deviation		6.1548	4.2072	7.7227	13.1063	19.7248	10.9533	9.7332	11.8965	8.1798	13.7827	21.6333	23.6344
Year		2004 – 2005											
	Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Stations	I	170.20	172.20	180.00	188.20	198.60	190.60	185.20	179.80	165.20	195.10	220.10	248.20
	II	180.10	180.10	185.60	195.60	200.30	195.20	188.10	172.10	168.30	180.20	245.20	265.20
	III	190.90	192.10	191.50	198.35	215.60	199.30	190.80	185.20	175.40	209.40	268.10	280.10
	IV	158.30	165.40	177.70	182.70	198.30	185.10	182.00	175.10	160.10	175.20	210.20	235.20
Mean		174.875	177.450	183.700	191.212	203.200	192.550	186.525	178.050	167.250	189.975	235.900	257.175
Standard Deviation		13.9126	11.4660	6.1682	7.1117	8.3134	6.1071	3.7853	5.7239	6.3992	15.464	26.0349	19.6078

According to Doneen's (1954) classification of irrigation water, water with conductivity values below 1000 µmhos is good for irrigation while with conductivity range of 1000-3000 µmhos belongs to good - hazardous class and >3000 µmhos belongs to hazardous - very hazardous class. As per this classification, Lake Mansar waters with conductivity range of 159.625 µmhos to 257.175 µmhos belong to very good to good class of irrigation water.

According to Wilcox's (1955) classification, waters with conductivity values <250 µmhos belongs to excellent class, 250-750 µmhos is good, 750-2000 µmhos is permissible, 2000-3000 µmhos is doubtful and >3000 µmhos is unsuitable. In the context of this classification, during first year of the present study, of the 48 samples, 47 belonged to excellent irrigation water class and 1 to good class. But during second year, 45 samples belonged to excellent class while 3 samples belonged to good class.

But according to USSL (1954), water with conductivity values below 750 µmhos is satisfactory for irrigation purposes and Lake Mansar waters with conductivity values well below 750 µmhos is satisfactory for irrigation purposes as it belongs to low salinity zone.

Perusal of Table 1 reveals that the conductivity values at each of the four study stations is satisfactory for irrigation purposes and that the conductivity recorded seasonal variations as being familiar tourist spot, Mansar lake receives variable number of tourists in different seasons.

b) Total Dissolved Salts

Almost all natural waters, even rain water, contain a variety of salts/solids, though their concentration may vary from one type of water to another. The concentration of total soluble salts in standing water bodies depends on the climate, geology, topography and influence of man (Maitland, 1978).

During the course of present investigations, on an average TDS values varied from 111.737±5.725 ppm (June) to 167.860± 16.584 ppm (Sept.) in the first year of study (Oct., 2003 to Sept., 2004) and from 117.075±4.479 ppm (June) to 180.022±13.725 ppm (Sept.) in the second year of the present study (Oct., 2004 to Sept., 2005) as depicted in the Figure 2.

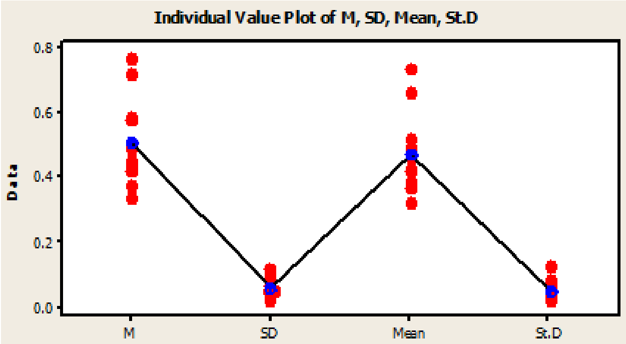


Figure 2. Range of Variation of Mean and Standard Deviation of Total Dissolved Solids during the 2003-2005

A careful analysis of the Table 2 reveals that TDS values recorded an increase in the concentration in the second year of the study with respect to the first year and the same could be attributed to the heavy rains that the study area experienced in the second year besides the increasing anthropogenic influences exerted mainly by heavy tourist inflow.

According to American Water Works Association (1971), waters having dissolved solid content less than or equal to 500mg/l are suitable for drinking and irrigation purposes. Since the TDS values of Mansar waters remained well below 500 mg/l, hence it could be inferred that the lake water is best suited for irrigation purposes.

Table 2. MONTHLY VARIATION IN TOTAL DISSOLVED SALTS (mg/l) ALONG THE FOUR STATIONS OF LAKE MANSAR

Year		2003 – 2004											
	Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Stations	I	115.08	125.09	127.54	128.94	143.64	128.80	127.19	126.00	112.00	128.80	147.14	157.50
	II	110.25	122.99	136.64	137.69	138.39	133.00	129.08	122.99	105.14	138.39	154.07	171.64
	III	115.08	129.99	139.37	150.64	168.14	143.57	140.56	138.39	119.07	147.49	175.14	189.56
	IV	107.80	125.48	134.75	134.75	140.56	126.14	125.48	119.14	110.74	126.42	140.07	152.74
Mean		112.052	125.887	134.575	138.005	147.682	132.875	130.577	126.630	111.737	135.275	154.105	167.860
Standard Deviation		3.6361	2.94551	5.0589	9.1744	13.8073	7.6673	6.8154	8.3275	5.7258	9.6479	15.1433	16.544
Year		2004 – 2005											
	Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Stations	I	119.14	120.54	126.00	131.74	139.02	133.42	129.64	125.86	115.64	136.57	154.07	173.74
	II	126.07	126.07	129.92	136.92	140.21	136.64	131.67	120.47	117.81	126.14	171.64	185.64
	III	133.63	134.47	134.05	138.84	150.92	139.51	133.56	129.64	122.78	146.58	187.67	196.07
	IV	110.81	115.78	124.39	127.89	138.81	129.57	127.40	122.57	112.07	122.64	147.14	164.64
Mean		122.412	124.215	128.590	133.847	142.240	134.785	130.567	124.635	117.075	132.982	165.130	180.022
Standard Deviation		9.7388	8.0262	4.3177	4.9765	5.8194	4.2749	2.6497	4.0067	4.4794	10.8251	18.2244	13.7255

Perusal of Table 2 furthermore reveals that TDS recorded a bimodal maxima, one during winter and the other during monsoons while during summer TDS recorded a decline and the same has already been discussed earlier.

Table 2 also indicates that TDS values at each of the four study stations recorded seasonal variations but never during the investigation period, TDS values exceeded the normal 500mg/l range.

c) Sodium Adsorption Ratio (SAR): Sodium concentration is of immense importance in classifying the water quality for irrigation. While a high salt concentration leads to the formation of saline soil, high sodium concentration leads to the development of alkaline soil. If the sodium value is high, alkali hazard results as the cation exchange complex may become saturated with sodium which can destroy soil structure owing to the dispersion of soil particles and conversely if Ca and Mg predominate the hazard is less. The sodium or alkali hazards in the use of water for irrigation is determined by the absolute and relative concentrations of cations especially sodium and is expressed as Sodium Adsorption Ratio (SAR). SAR provides a means to evaluate the potential base-exchange relationships in which soil calcium and magnesium are displaced by sodium in irrigation waters. With increasing SAR values, plants of greater salt tolerance may be required. So irrigation water with low SAR is desirable.

During the present study mean SAR values varied from 0.331±0.071 meq/l (June) to 0.761±0.117 meq/l (August) in the first year of study (Oct. 2003 to Sept.2004) and from 0.361±0.046 meq/l (May) to 0.732±0.074 meq/l (Sept.) in the second year of the study (Oct. 2004 to Sept.2005) (Table 3) as depicted in the Figure 3.

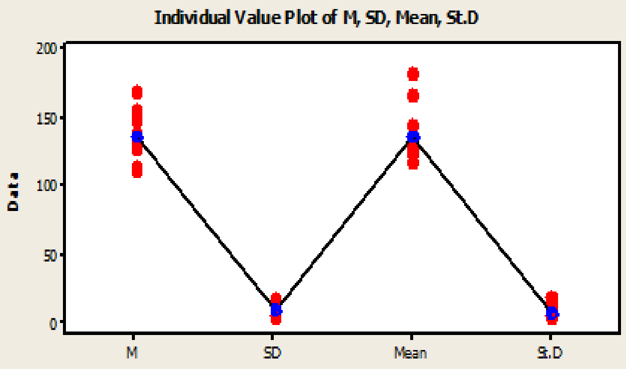
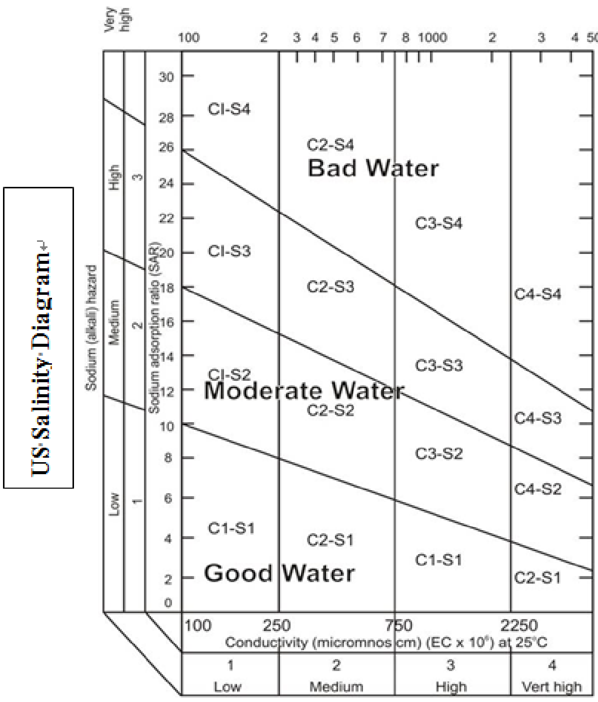


Figure 3. Range of Variation of Mean and Standard Deviation of Sodium Adsorption Ration during the 2003-2005

Table 3. MONTHLY VARIATION IN SODIUM ADSORPTION RATIO (meq/l) IN LAKE MANSAR

Year	**2003 – 2004**												
	Months	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
Stations	**I**	0.472	0.462	0.464	0.510	0.586	0.458	0.461	0.434	0.275	0.601	0.746	0.652
	II	0.294	0.493	0.483	0.421	0.538	0.456	0.383	0.396	0.285	0.692	0.921	0.784
	III	0.471	0.399	0.452	0.507	0.595	0.540	0.484	0.462	0.452	0.585	0.786	0.725
	IV	0.259	0.366	0.381	0.551	0.578	0.471	0.411	0.387	0.314	0.449	0.591	0.704
Mean		0.374	0.422	0.445	0.497	0.574	0.481	0.434	0.419	0.331	0.581	0.761	0.716
Standard Deviation		0.098	0.060	0.038	0.047	0.021	0.034	0.039	0.030	0.071	0.086	0.117	0.047
Year	**2004 – 2005**												
	Months	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
Stations	**I**	0.493	0.476	0.524	0.508	0.523	0.410	0.433	0.300	0.407	0.525	0.833	0.827
	II	0.423	0.463	0.366	0.450	0.466	0.410	0.371	0.392	0.314	0.522	0.668	0.720
	III	0.538	0.406	0.352	0.494	0.493	0.357	0.411	0.309	0.385	0.532	0.625	0.760
	IV	0.499	0.326	0.456	0.390	0.458	0.339	0.326	0.266	0.341	0.486	0.490	0.622
Mean		0.488	0.417	0.424	0.460	0.485	0.379	0.385	0.316	0.361	0.516	0.654	0.732
Standard Deviation		0.041	0.059	0.069	0.045	0.025	0.031	0.040	0.046	0.036	0.017	0.122	0.074



On the basis of SAR values, US Salinity Laboratory Staff (1954) has classified irrigation water into excellent class (SAR < 10 meq/l), good class (SAR = 10-18 meq/l), fair class (SAR =18-26 meq/l) and poor class (SAR > 26 meq/l). The Lake Mansar waters with SAR values less than 10meq/l are suitable for irrigation purposes according to USSL (1954) classification.

Perusal of Table 3 also reveals that SAR recorded seasonal variability, with maxima during winter and monsoons and a decline during summer.

While decrease in phytoplankton population and macrophytes leading to reduced uptake or consumption of cations especially Na and decomposition of organic matter could lead to winter maxima, monsoon maxima may be due to leaching of sodium salts, sewage, faecal matter, decaying organic matter, silt etc into the domain of lake from the catchment area.

Likewise summer decline may be attributed to active utilization of sodium by photosynthetically active phytoplanktons and adsorption of sodium to clay particles.

Moreover, when these SAR values were plotted in US Salinity Diagrams against conductivity/salinity hazards, the diagrams reveal that the lake water belong to C_1S_1 (Low Salinity, Low SAR) class which implies that the water is excellent for irrigation purposes.

A careful analysis of the Table 3 reveals that the SAR values increased from 0.331 to 0.361 though maximum values showed improvement from 0.761 to 0.732meq/l.

d) Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate is yet another indicator of the danger of increased sodium concentration in soil because it takes into account the precipitation of Ca and Mg as carbonates and bicarbonates once the water comes in contact with the soil and propitiates the reduction of the antagonist effects of these two divalent cations on the sodium. Moreover, increased levels of sodium in water has been observed to provoke a natural increase in the sodium bicarbonate content and in soil pH, that could cause physiological deficiency of iron which from nutritional point of view is difficult to manage (Uvalle-Bueno *et al*, 1996). If water contains higher concentration of bicarbonate ions, calcium ions tend to precipitate as carbonates and consequently relative concentration of sodium ion increases which gets fixed in the soil by base-exchange mechanism and reduce the soil permeability.

During the present study, average RSC values (Table 4) were found to vary from 1.269±0.174 meq/l (Oct.) to 2.372±0.179 meq/l (Aug.) in the first year of study (Oct. 2003 to Sept. 2004) and from 1.159±0.123 meq/l (Oct.) to 2.379±0.135 meq/l (Aug.) in the second year of study (Oct. 2004 to Sept. 2005) as shown in the Figure 4.

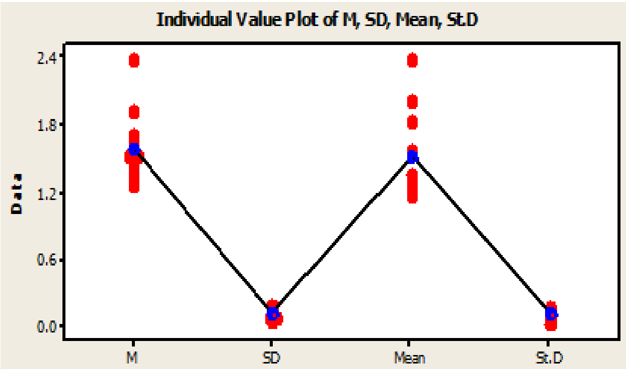


Figure 4. Range of Variation of Mean and Standard Deviation of Residual Sodium Carbonate during the 2003-2005

Table 4. MONTHLY VARIATION IN RESIDUAL SODIUM CARBONATE (meq/l) IN LAKE MANSAR

Year	2003 – 2004												
	Months	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
Stations	**I**	1.464	1.328	1.426	1.255	1.540	1.504	1.583	1.673	1.670	1.984	2.430	1.479
	II	1.208	1.399	1.362	1.327	1.471	1.396	1.183	1.608	1.653	1.820	2.433	1.474
	III	1.391	1.575	1.576	1.527	1.639	1.645	1.568	1.782	1.770	1.988	2.553	1.661
	IV	1.015	1.220	1.477	1.237	1.451	1.355	1.319	1.570	1.742	1.891	2.073	1.487
Mean		1.269	1.380	1.460	1.336	1.525	1.475	1.413	1.658	1.708	1.920	2.372	1.525
Standard Deviation		0.174	0.129	0.078	0.115	0.073	0.112	0.169	0.080	0.048	0.069	0.179	0.078
Year	**2004 – 2005**												
	Months	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
Stations	**I**	1.229	1.420	1.391	1.271	1.408	1.333	1.415	1.606	1.703	2.084	2.539	1.833
	II	1.062	1.310	1.219	1.112	1.307	1.154	1.078	1.536	1.498	1.894	2.318	1.774
	III	1.324	1.494	1.404	1.341	1.450	1.443	1.250	1.614	1.599	2.213	2.469	1.831
	IV	1.021	1.090	1.154	0.965	1.270	1.474	1.236	1.474	1.491	1.814	2.190	1.832
Mean		1.159	1.328	1.292	1.172	1.358	1.351	1.244	1.557	1.572	2.001	2.379	1.817
Standard Deviation		0.123	0.152	0.108	0.145	0.072	0.125	0.119	0.056	0.086	0.156	0.135	0.025

Aceves (1979) indicated that the irrigation water according to the range of RSC content could be classified as good water (RSC< 1.25 meq/l), marginal water (RSC=1.25 meq/l to 2.50 meq/l) and unsuitable water (RSC > 2.50 meq/l) as it improvises the risk of sodium build up in the soil. With RSC values varying from 1.159 meq/l to 2.379 meq/l in the study area during the course of present investigation, Mansar Lake seems to belong to marginal class for irrigation purposes. But during first year, of the total 48 samples, 4 belonged to safe class, 43 to marginal class and 1 to unsuitable class. In contrast to the first year during second year, of the 48 samples, 12 belonged to safe class, 35 to marginal class and 1 to unsuitable class. So it seems that the RSC values of Mansar waters improved in second year with respect to first year as number of samples in safe class leapfrogged to 12. This rise in the number of samples in safe class may be attributed to the dilution effect induced by incessant rains that the study area received during the year 2005.

Perusal of Table 4 further reveals that RSC values recorded bimodal maxima, one during monsoons and the other during winter. While during summer, RSC values recorded an increase.

While winter maxima in RSC concentration may be attributed to reduced water level, decomposition of organic matter and increased bicarbonate content, monsoon maxima may be due to surface run-off along with nutrients and soils from catchment area (Carrillo-Rivera, 2000), inflow of sewage and agricultural overland flow.

Steady increase in RSC values during summer may be due to the influx of detergents, wastes, faecal matter, cattle bathing, inflow of sewage and an increase in macrophytic population which release nutrients absorbed from the soil into the water.

The Table 4 is indicative of the fact that RSC values varied seasonally at each of the four study stations. Of all the four stations, station III recorded maximum values followed by stations I, II and IV respectively, which implies that station III is under acute anthropogenic stress in comparison to other stations.

e) Soluble Sodium Percentage (SSP)

The relative proportion of sodium to other cations in irrigation water is simply expressed as the percentage of sodium among the principle cations. Soluble sodium percentage is thus a measure of sodicity as it indicates the proportion of sodium adsorbed on to the clay mineral surfaces.

Perusal of Table 5 reveals that during the first year of study (Oct. 2003 to Sept. 2004), SSP varied from 22.432±2.983 meq/l (June) to 44.877±5.131 meq/l (Aug.) But during second year (Oct. 2004 to Sept. 2005), SSP values on an average varied from 21.110±1.300 meq/l (March) to 39.625±2.718 meq/l (Sept.) as shown in Figure 5.

Table 5. MONTHLY VARIATION IN SOLUBLE SODIUM PERCENTAGE (meq/l) IN LAKE MANSAR

Year		2003 – 2004											
	Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Stations	I	28.85	26.21	24.50	27.78	43.60	27.01	29.37	26.17	19.72	37.93	43.00	36.46
	II	21.98	25.86	24.43	24.22	28.42	25.48	23.46	23.85	19.46	39.47	53.19	44.51
	III	26.13	22.33	22.58	27.57	30.83	29.08	27.38	26.70	26.55	34.84	44.11	33.21
	IV	17.92	20.09	21.45	30.63	32.47	27.91	26.69	21.70	24.00	36.98	39.21	42.38
Mean		23.720	23.622	23.240	27.550	33.830	27.370	26.725	24.605	22.432	37.305	44.877	39.140
Standard Deviation		4.174	2.542	1.288	2.270	5.821	1.315	2.126	1.990	2.983	1.677	5.131	4.518
Year		2004 – 2005											
	Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Stations	I	28.70	27.09	28.04	26.02	26.58	22.71	26.13	21.55	23.97	31.79	46.19	44.22
	II	26.30	26.57	22.02	24.48	23.99	22.05	21.15	22.86	19.31	28.24	36.00	38.41
	III	29.08	23.03	20.48	24.68	23.81	19.62	20.51	19.09	20.68	27.21	32.34	38.73
	IV	29.48	21.20	24.51	22.18	24.58	20.06	20.65	18.75	26.76	31.90	31.97	37.14
Mean		28.390	24.472	23.762	24.350	24.740	21.110	22.110	20.562	22.680	29.785	36.625	39.625
Standard Deviation		1.237	2.451	2.857	1.380	1.099	1.300	2.333	1.710	2.901	2.092	5.742	2.718

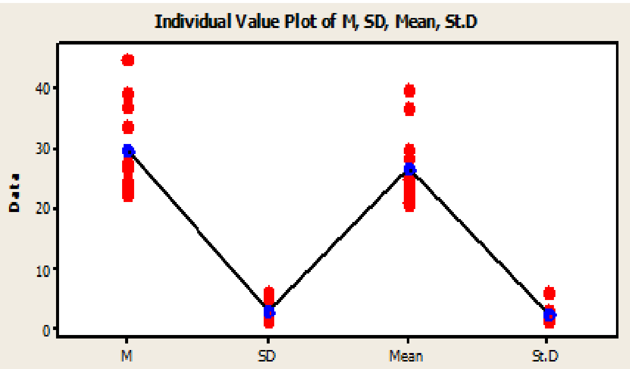


Figure 5. Range of Variation of Mean and Standard Deviation of Soluble Sodium Percentage during the 2003-2005

According to Doneen (1954), waters with soluble sodium percentage values of <60meq/l belong to very good - good class, with 60 – 70meq/l belong to good to hazardous class and with >70 meq/l belong to hazardous – very hazardous class. In the context of this classification Mansar waters with SSP varying from 21.110meq/l to 44.877meq/l fall in very good to good class. So Mansar Lake water is ideal for irrigation purposes.

But Wilcox (1955) put forth new irrigation water quality criteria, according to which Mansar waters are good for irrigation. As per this classification, during first year, of the total 48 samples, 3 belonged to excellent class, 39 to good class and 6 to permissible class. But during second year, of the 48 samples, 4 belonged to excellent class, 42 to good class and 2 to permissible class. So the Mansar waters are improving in terms of irrigation quality as the number of samples in permissible class in the second year of study was found to be reduced to 2 only.

In fact, Table 5 also reveals that SSP recorded well marked seasonal variations although the variability in the percentage sodium observed during first year is in quite contrast to the variability recorded in second year of the study and the same may be attributed to the ability of the primary producers to consume sodium which seems to be more efficient in second year than the first year of study. Moreover, seasonal variability is also well evident at each of the four study stations wherein greatest values of % Na were recorded at stations III and II for most of the study period in comparison to other two (I and IV) stations (Table 5). And the variability at each of the four stations is quite different from each other, which could be due to the differential nature of anthropogenic stress that these stations are vulnerable to.

f) Doneens Permeability Index (DPI)

Long time effects of irrigation water quality on the physical properties of soil depends mainly on total salts, sodium, carbonate and bicarbonate concentrations of irrigation waters and on initial soil properties of soil itself (Raghunath, 1987). Accurate irrigation water quality is thus the best preventive measure to reduce salinity and sodicity effects.

Doneen (1966) proposed a concept called as ‘permeability index’ to assess the probable influence of water quality on the physical properties of soils.

During the course of present study, DPI values varied from 40.230±1.025 (Dec.) to 81.507±8.249 (Aug.) in the first year (Oct. 2003 to Sept. 2004) and from 38.006±2.201 (Mar.) to 64.978±10.637 (Aug.) in the second year (Oct. 2003 to Sept. 2004) of present study as shown in Figure 6.

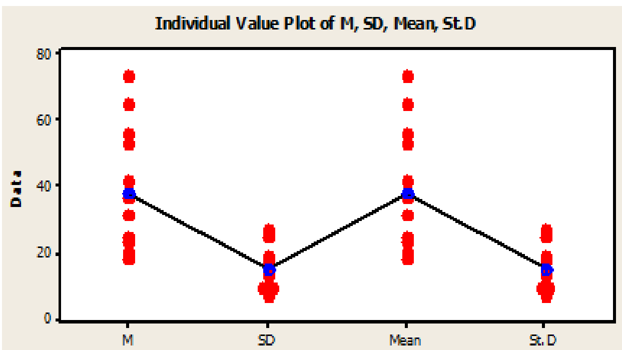


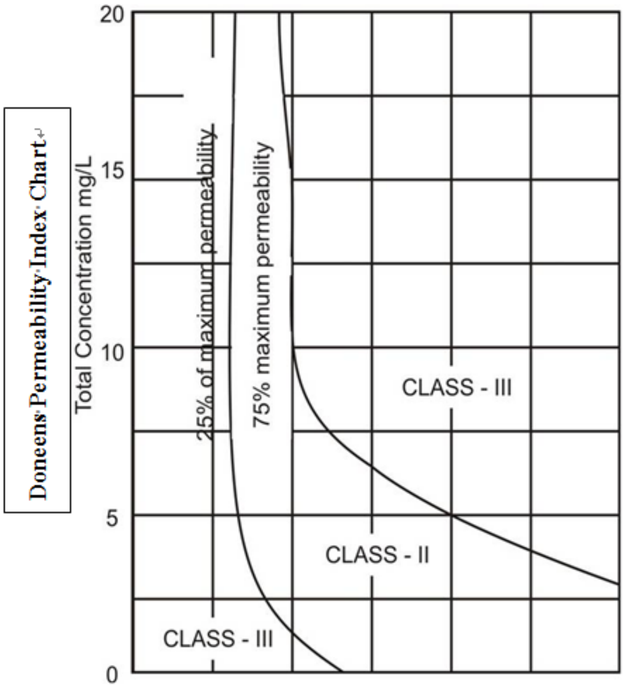
Figure 6. Range of Variation of Mean and Standard Deviation of Doneens Permeability Index during the 2003-2005

Moreover, Table 6 also reveals that DPI values varied seasonally with an increasing trend towards monsoons from winter and a declining trend from monsoons toward winter.

Table 6. MONTHLY VARIATION IN DONEENS PERMEABILITY INDEX (meq/l) IN LAKE MANSAR

Year		**2003 – 2004**											
	Months	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
Stations	**I**	49.755	43.796	41.333	44.053	47.538	48.887	56.510	53.572	50.874	72.805	75.061	55.882
	II	39.229	42.903	40.288	40.032	45.155	44.376	41.811	46.456	46.124	68.738	95.671	69.651
	III	43.938	40.738	38.575	44.631	50.540	51.089	50.072	52.687	57.248	63.119	78.022	55.172
	IV	37.785	38.548	40.724	50.928	55.845	52.219	55.056	56.653	70.118	90.211	77.275	70.654
Mean		42.676	41.496	40.230	44.911	49.769	49.142	50.862	52.342	56.091	73.718	81.507	62.839
Standard Deviation		4.677	2.033	1.025	3.899	3.993	3.001	5.745	3.703	9.009	10.124	8.249	7.325
Year		**2004 – 2005**											
	Months	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
Stations	**I**	48.465	46.470	45.408	43.217	43.158	40.386	48.298	48.140	51.381	61.084	82.106	68.076
	II	45.517	45.601	40.408	40.036	39.177	36.750	37.664	43.859	43.504	51.598	61.288	59.459
	III	46.672	40.986	37.161	39.652	38.973	35.045	36.607	38.576	40.866	47.504	53.000	57.747
	IV	50.167	37.161	41.559	38.536	41.367	39.845	41.207	44.384	50.020	55.487	63.518	63.836
Mean		47.705	42.554	41.134	40.357	40.668	38.006	40.944	43.739	46.442	53.918	64.978	62.279
Standard Deviation		1.767	3.747	2.947	1.741	1.716	2.201	4.574	3.407	4.385	5.008	10.637	4.016

According to Doneen's Permeability Index Chart, Mansar waters fall in class-II category, thereby implying that the lake water is good for irrigation purposes at all the sampling stations in both the years of present study.



From the above discussions, it is clear that the water of Lake Mansar is ideal for irrigation purposes yet the same needs to be checked / prevented as this charismatic inland depression provides employment to a number of people living around besides the ground water recharge, stability of the micro-climate and providing potable water to about 20,000 people.

Acknowledgements

I am thankful and indebted to the Head Department of Zoology, University of Jammu, Jammu for providing laboratory and library facilities.

References

[1] Aceves, E. El ensalitramiento de los suelos bajo riego. Coliego de Postgraduados. Chapingo, Mexico. 1979.

[2] APHA. Standard Methods for the Examination of Water and Waste Water. 14th Ed. American Public Health Association, New York. 1975.

[3] Ayers, R.S. and Westcot, D.W. Water quality for agriculture. FAO irrigation and drainage paper 29 Rev. 1, FAO, Rome. 97pp. 1994.

[4] Castellanos, J.Z., Ortega-Gurrero, A., Gradeja, O.A., Vazquez, A.A., Villalobas, S., Munoz-Ramos, J.J., Zamudio, B., Martuiez, J.G., Hurtado, B., Vargas, P. and Enriquez, S.A. Changes in the quality of ground water for agricultural use in Guanajuato. *TERRA*, 20(2): 161-170. 2002.

[5] Christiansen, K.K., Anderson, F.O. and Jensen, H.S. Comparison of iron, manganese and phosphorus retention in freshwater littoral sediment with growth of *Littorella uniflora* and benthic microalgae. *Biogeochemistry*, 38: 149-171. 1997.

[6] Doneen, L.D. Salinization of soils by salt in irrigation water. *Trans. Amer. Geophy. Union*, 35: 943-950. 1954.

[7] Doneen, L.D. Water quality requirement for irrigation. Proc. National Symp. Quality Standards for National Waters. University of Michigan, *Ann. Report*. pp. 213-218. 1966.

[8] Graham, W.B.R., Pishiria, I.W. and Ojo, O.I. Monitoring of groundwater quality for small scale irrigation: Case studies in the Southwest Skoto-Rima basin, Nigeria. *Agricultural Engineering International*, VIII: 1-9. 2006.

[9] I.S.I. Indian Standard Methods for Sampling and Test (Physical and Chemical) for water used in Industry. Indian Standard Institute, Manak Bhavan, New Delhi. 1973

[10] Kirda, C. Assessment of irrigation water quality. CIHEAM - Options Mediterraneennes, Ser. A., No. 31, pp. 367-377. 1977.

[11] Krishnan, P.V. and Prasad, R. Tectonic framework of a tertiary belt of the Sub-Himalayas of Jammu. Publication Centre Advance studies Geology, Chandigarh, No. 7-19. 1970.

[12] Kudesia, V.P. Water Pollution. (Principles of disinfection of drinking water and its analysis Ist Edn. K.K. Mittal, Pragati Prakashan. Meerut, India. 1980.

[13] Landon, J.R. Booker Tropical Soil Manual. Longman Scientific and Technical, Booker Tate, New York. 1991.

[14] Maitland, P.S. Biology of Fresh waters, Ist ed. Blackie and Son Limited, Bishopbriggs Glasgow. G642NZ. 1978.

[15] NIH: Ground water quality monitoring and evaluation of Jammu and Kathua Districts, J&K. Technical Report No. CS (AR)-21/97-98. pp. 1-40. 1998.

[16] Raghunath, H.M. Ground water, Second Edition. Wiley Eastern Limited Ansari Road, Darya Ganj, New Delhi – 110 002. 1987.

[17] Singh, B.R. Quality of irrigation water in fadama lands of northwestern Nigeria. 2. Ground and surface waters in Kebbi State. *Nigerian J. Basic Appli. Sci*., 9(2): 133-148. 2000.

[18] Singh, O., Rai, S.P., Kumar, V., Bhatia, K.K.S. and Choubey, V.K. Water quality and eutrophication status of some lakes of different regions in Jammu & Kashmir (India). In: Urban lakes in India: Conservation, Management and Rejuvenation (Eds. Bhatia, K.K.S. and Khobragade, S.D.), Part-I, pp. 92-100. 2005

[19] Stevens, D.P., McLaughlin, M.J. and Smart, M.K. Effects of long-term irrigation with reclaimed water on soils of the Northern Adelaide Plains, South Australia. *Australian Journal of Soil Research.* http://WWW.highbeam.Com/library/doc3.asp/ DOCID=1G1:108721957 &num= 1&ctrlinfo=1-16. 2003.

[20] Todd, D.K. Groundwater Hydrology, Second Edition. Wiley & Sons Inc., New York. 535pp. 1980.

[21] U.S.S.L. Diagnosis and improvement of Saline & Alkali Soils. US Handbook No. 60, U.S. GPO, Washington D.C., USA. 1954.

[22] Uvalle-Bueno, J.X., Limon, G.J.F. and Osorio, A.R. Application foliar de nitrato de potasio en algodonero nacional de la Ciencia del Suelo. La Investigacion Edafologica en Mexico 1995-1996.

[23] Wetzel, R.G. Limnology: Lake and River Ecosystems. 3rd Edition. Academic Press: A Harcourt Science and Technology Company, 525B Street, Suite 1900, San Diego, California. pp.1000. 2001.

[24] Wilcox, L.V. Classification and use of irrigation waters. U.S. Deptt. Agric. Circ. 969, Washington, D.C. pp. 19. 1955.