IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 10- Issue 01, January 2023
ISSN (Online) 2348 – 7968 | Impact Factor – 6.72
www.ijiset.com

Irrigation Water Quality Assessment of Secondary Treated Wastewater of A Residential Colony STP

Rinku Chawla
Associate Professor, SSGC Govt College, Suratgarh, Rajasthan, rchawla0250@gmail.com

ABSTRACT

Water reuse for crop irrigation becomes necessary due to high water demand of the agriculture sector and limited water resources. The present paper aims to assess water quality of secondary treated wastewater of a sewage treatment plant located in a residential colony Ridhi-Sidhi Enclave, Sri Ganganagar, Rajasthan, India. The study involves computation of irrigation indices in terms of salinity and sodicity of treated water used mainly for landscape and crop irrigation. Salinity is evaluated using measured values of EC and TDS. Sodicity is interpreted in terms of SAR, PSS, RSC, MAR and PI data. The salinity results show that treated water of this site requires some management and should be diluted for sensitive plant watering. Sodicity parameters are in safe range and suitable for landscape irrigation. Correlation study among various parameters shows relationship among themselves and are useful to get a good understanding of irrigation water quality by computing few parameters. PI values share significant linear relationship ($0.5 < r < 0.8$) with PSS, RSC and MAR irrigation water quality parameters and can be used to express irrigation water quality.

KEY WORDS

water reuse, irrigation water quality, irrigation water indices, salinity, sodicity.

INTRODUCTION

Population growth, urbanisation, industrial growth, agriculture sector etc. are major contributors of water consumption and water stress. About 70% of water used in various domestic and commercial activities is released as wastewater. Improper disposal of wastewater leads to water pollution and creates a big problem. 70% water withdrawals globally and over 90% in the developing countries are used in agricultural activities. According to [1] expected water consumption would lead the population growth in many parts of the world. In this scenario, wastewater reclamation is the crucial requirement and is attracting global attention [2]. Urban wastewater reuse around the world is quite feasible in sustainable management of

the world's total water demand [3] and to cope up with large scale use in agriculture. The use of wastewater helps to close the loop between water supply and wastewater disposal [4]. Minimum wastewater discharge in turn helps to protect aquatic environments [5]. Domestic sewage and bio-industrial effluents are rich in organic matter and plant nutrients, the agriculture sector opens a cheaper and big way of their disposal [6], [7]. Urban and peri-urban areas in most of the developing countries are using treated, poorly treated, diluted or even raw wastewater for irrigation [8], [9], [10]. According to [11], about 73000 ha of land in India is irrigated using wastewater. There are several advantages and disadvantages in using sewage water for irrigation purpose [12]. [13], [14] studied the effect of irrigation by domestic wastewater on soil properties. Maintaining the nutrient content during wastewater treatment is viable for circular economy and support sustainable development [15]. Excessive nutrient content in irrigation water may adversely affect plant growth and cause plant toxicity [16]. Use of reclaimed water in agriculture is very sensitive issue, associated with human health, environment health and aesthetic sense. Therefore, water quality monitoring is very important to keep a check on water health. The present paper emphasizes on computation and evaluation of irrigation indices of secondary treated wastewater used for landscape irrigation.

STUDY AREA

Sri Ganganagar town is the district headquarter of Sri Ganganagar district of Rajasthan. The town is situated in the northern most region of Rajasthan, with having borders with Pakistan in north and north-western direction and with Punjab in the north and north-eastern direction. The town is situated at latitude $29^0$58' north and longitude 73^0 50' east. The urban growth of the town is leading to expansion of built-up areas and other infrastructure. Along with other resources, water consumption and wastewater production increases accordingly. To improve public health, clean and green environment and conservation of precious water resources, the Governments have mandated the establishment of sewage treatment plants in the residential colonies. Ridhi-Sidhi Enclave, Sri Ganganagar– a residential colony is equipped with domestic sewage treatment plant since 2008 with capacity of 400 KLD. Domestic sewage of the colony is collected in raw water storage tank from there it flows through aeration tank, recirculation tank, chlorination tank, passes through sand and carbon filters. This reclaimed water is used to irrigate parks of the colony as well for construction sites. To study the irrigation water indices and other quality parameters of this treatment plant, measurements were made for a period of one year from February 2020 to January 2021. The present paper focuses on computation and evaluation of irrigation water indices from measured physicochemical parameters.

MATERIALS AND METHODOLOGY

Composite method of sampling was adopted for the present research work [17],[18]. Good quality narrow mouth screw-capped water bottles of two litre capacity made of polypropylene were used to collect the samples. Before sample collection bottles were rinsed thrice with water to be sampled and then filled completely to avoid any air bubble [19], [20]. Sampling was done in the morning and evening time. Temperature, pH and DO were noted in the field at the time of sampling. For other parameters, the samples were refrigerated immediately and then mixed. The detailed analysis of all the composite samples was carried out using standard methods given in [21]. TH, TA were measured by titrimetric method, EC by using systronics laboratory conductivity meter. Na^+ and K^+ were measured using systronics flame photometer. The measured parameters were used to compute various irrigation water indices as per table-1.

Table.1 Computation of Irrigation Water Quality Indices

Quality Index	Formula
Sodium Adsorption Ratio (SAR)	$Na^+/ ((1/2(Ca^{2+} + Mg^{2+}))^{1/2})$
Percent Soluble Sodium (PSS)	$Na^+/ (Na^+ + (K^+ + Ca^{2+} + Mg^{2+}) * 100$
Residual Sodium Carbonate (RSC)	$CO_3^{2-} + HCO_3^- (Ca^{2+} + Mg^{2+})$
Magnesium Adsorption Ratio (MAR)	$(Mg^{2+})/ (Mg^{2+} + Ca^{2+}) * 100$
Permeability Index (PI)	$(Na^+ + (HCO_3^-)\text{^}0.5)/(Ca^{2+} + Mg^{2+} + Na^+) * 100$

*All parameters used in formulae are in meq/l units.

Table-2: Irrigation Water Indices (RS STP Sri Ganganagar)

Sample	EC	TDS	PSS	SAR	RSC	MAR	PI
RS1	870	510	0.49	2.81	-0.42	48.28	74.15
RS2	745	418	0.51	2.89	-0.29	45.71	76.69
RS3	820	492	0.49	2.88	-0.16	47.69	75.36
RS4	980	576	0.50	3.02	0.05	49.79	76.04
RS5	1280	605	0.45	2.75	-0.77	50.71	67.91
RS6	1080	576	0.52	3.01	-0.55	46.80	76.71
RS7	970	546	0.51	2.79	-0.55	46.57	76.37
RS8	920	532	0.51	2.71	-0.40	43.08	77.72
RS9	870	560	0.48	2.47	-0.46	50.26	75.47

RS10	842	512	0.45	2.27	-0.33	44.12	74.06
RS11	868	543	0.48	2.67	-0.44	49.41	74.82
RS12	890	564	0.48	2.72	-0.51	49.26	74.10
RS13	860	516	0.46	2.53	-0.34	47.14	73.45
RS14	810	508	0.44	2.32	-0.88	49.22	69.87
RS15	832	520	0.50	2.95	-0.86	48.73	73.73
RS16	850	540	0.50	2.94	-0.83	46.26	73.00
RS17	876	556	0.51	3.04	-0.78	49.22	73.95
RS18	820	528	0.50	2.91	-0.76	50.26	73.74
RS19	780	510	0.48	2.71	-0.69	49.55	72.65
RS20	810	528	0.48	2.76	-0.78	49.04	72.41
RS21	846	548	0.48	2.81	-1.02	48.36	71.23

Table-3: Correlation Matrix of Irrigation Water Indices

	EC	**TDS**	**PSS**	**SAR**	**RSC**	**MAR**	**PI**
EC	1.000						
TDS	0.750	1.000					
PSS	-0.060	-0.046	1.000				
SAR	0.168	0.136	0.829	1.000			
RSC	0.018	-0.190	0.162	-0.028	1.000		
MAR	0.148	0.395	-0.194	0.137	-0.280	1.000	
PI	-0.201	-0.234	0.718	0.270	0.642	-0.504	1.000

RESULTS AND DISCUSSION

To assess water quality of secondary treated wastewater of RS STP for irrigation purpose, salinity and sodicity were computed using measured physicochemical parameters. Salinity of water samples was evaluated using measured values (table-2) of electrical conductivity (EC) and total dissolved solids (TDS). Sodicity is confronted in terms of poor infiltration and inadequate permeability of water in soil. Irrigation with high sodium water for long term may cause swelling of soil clays and pore plugging. Sodicity is mainly assessed in terms of SAR (sodium adsorption ratio), PSS (percent soluble sodium), RSC (residual sodium carbonate) and MAR (magnesium adsorption ratio). The potential for sodicity related soil problems is discussed in terms of permeability index (PI). The computed values are shown in Table-2.

Conductivity of water varies directly with the temperature and is proportional to its dissolved inorganic solids. Most of the matter in water samples is in dissolved form and consist mainly of inorganic salts such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, CO_3^{2-}, HCO_3^{-} and small amounts of

organic matter, dissolved gases, which contribute to EC and TDS [22]. EC of 95% of samples fall under medium hazard category and such water use requires some management [23]. The present study reveals that average TDS values for RS STP (532.7±38.2) are higher than prescribed BIS standard of drinking water (500mg/l) but are within limits for irrigation and reuse purposes (2000mg/l) [24]. According to [23] classification of irrigation water, RS STP treated water may cause medium hazard to sensitive crops and should be used with some management. SAR value is an important tool to assess sodium hazard of irrigation water. High SAR values prevent water from reaching plant branches and leaves by reducing the osmotic action. In this study, as per SAR values, the treated water from RS STP could be classified as low sodium hazard (S_1) to soil [25]. The PSS values are related to soil permeability, so is very important in categorizing irrigation waters. The average PSS values (48.7%) of the study area are permissible for irrigation [26]. None of the samples was found unfit for irrigation. Residual sodium carbonate (RSC) is another indicator of sodium hazard in irrigation water. RSC values indicate sodium carbonate compared to calcium and magnesium and contribute to soil alkalinity. High RSC values in irrigation waters may affect plant growth and lead to solid scale formation in irrigation systems as well. A negative value of RSC reveals higher concentration of Ca^{2+} and Mg^{2+}. Values of RSC less than 0.5 indicate that sodium buildup is unlikely since sufficient calcium and magnesium are more than that can be precipitated as carbonates. The average RSC values of present study site (-0.56) indicate good quality irrigation water and fall in the safe range for irrigation [27], [28]. MAR is measure of potential of magnesium to displace calcium in soil thereby affecting soil structure and plant growth. High magnesium relative to calcium has negative impact on soil structure and plant growth. Generally, water with MAR value more than 50 indicates water treatment or alternative irrigation strategies [27]. The MAR values of the study area show that 86% samples are suitable for irrigation [28]. The PI value shows the long-term exposure effects of high Na^+, Ca^{2+}, Mg^{2+} and alkalinity ions in irrigation waters. All the samples of study area fall under class I and II [29] with 33% samples of class I and 67% samples of class II and are recommended for irrigation. The average PI values, 74.0±2.35 show high permeability and aeration in soil.

Correlation study of irrigation water quality indices - In the present study, the Karl Pearson Matrix was used to identify statistically significantly correlated irrigation indices. Correlation coefficient (r) between any two indices x and y is calculated for EC, TDS, SAR, PSS, RSC, MAR and PI of the undertaken samples and are presented in Table-3. The degree of line association between any two of the irrigation water quality parameters as measured by simple

correlation coefficient (r) is presented as 7*7 correlation matrix. Out of the 28 correlation coefficients, correlation coefficient (r) between SAR and PSS is observed 0.8285 with highly significant level ($0.8 < r < 1.0$). Correlation coefficient values, EC vs TDS ($r = 0.7499$), PSS vs PI ($r = 0.7181$) and RSC vs PI ($r = 0.6423$) give the moderate significant ($0.6 < r < 0.8$) level of r values. The significant negative correlation value between MAR and PI ($r = -0.5038$) indicates negative correlation between MAR and PI. MAR value is a measure of potential of magnesium to displace calcium in soil. High magnesium relative to calcium has negative impact on soil structure that reduces water permeability and has negative impact on plant growth. Negative correlation between PI and EC, TDS show that high salt values in irrigation water block the soil pores and reduce soil permeability.

CONCLUSION

Use of reclaimed water for irrigation helps to address water scarcity issue, save water for other applications and preserve freshwater resources. It is very sensitive issue, associated with ecosystem health, environment health and aesthetic sense. To ensure safe and long-term irrigation using treated water requires continuous water quality monitoring, careful irrigation procedures to encourage sustainable agriculture practices. The results of present study show that EC and TDS values of study area indicate medium hazard to soil. PSS, MAR and PI values are permissible for irrigation, but their long-term use may affect soil, plant and human health as well. Such water uses still require better treatment, some dilution and regular monitoring of treatment plants as well as soil and water quality assessment. A systematic correlation study showed high significant linear relationship among SAR-PSS, EC-TDS, PSS-PI, RSC-PI and MAR-PI pairs of irrigation water quality parameters. PI values share linear relationship with other irrigation water quality parameters and can be used to express irrigation water quality.

REFERENCES

[1] Islam S.M.F. , Karim Z., World's demand for food and water: The consequences of climate change, Desalination-challenges and opportunities, 1–27 (2019).

[2] Heurtas E., Salgot M., J. Hollender, Weber S., Dott W., Khan S., Schafer A., Messaslem R., B. Bis, Aharoni A. , Chikurel H. , Key objectives for water reuse concepts, Desalination, 218 (2008), pp. 120-131.

[3] Anderson J. (2003). The environmental benefits of water recycling and reuse. Water Science and Technology; Water Supply, 3(4) 1-10.

[4] Bahril A., Drechsell P. and Brissaud F. (2007). Water reuse in Africa; challenges and opportunities, International Water Management Institute, Africa 2007, Working Paper 128 Wastewater Reuse and Recycling Systems; A Prespective into India and Australia.

[5] Becerra-Castro C. , A.R. Lopes, I. Vaz-Moreira, E.F. Silva, C.M. Manaia, O.C. Nunes, Wastewater reuse in irrigation: a microbiological perspective on implications in soil fertility and human and environmental health, Environ. Int., 75 (2015), pp. 117-135,

[6] Nag Jyothi P.C., Dinakar N., Suresh S., Udaykiran Y., Suresh C. and Damodharam T. (2009). Effect of industrial effluent on the morphological parameters and chlorophyll content of green gram (PhaseolusaureusRoxb). Journal of Environmental Biology Vol. 30, 385-388.

[7] Nath K., Singh D., Shyam S., Sharma Y.K., (2009). Phytotoxic Effects Of Chromium And Tannery Effluent On Growth And Metabolism Of PhaseolusMungoRoxb. , Journal Of Environmental Biology, Vol.30 (2), 227-234.

[8] Hamilton A.J., Stagnitti F. et. al. (2007). Wastewater irrigation: the state of play. Vadose Zone J 6(4): 823-840.

[9] Keraita B., Jiménez B., Drechsel P. (2008). Extent and implications of agricultural reuse of untreated, partly treated and diluted wastewater in developing countries. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 3: 1-15.

[10] Scott C.A., Faruqui N.I., Raschid-Sally L. (2004). Wastewater use in irrigated agriculture: confronting the livelihood and environmental realities. CABI Publishing, Wallingford, UK.

[11] Singh P.K. , Deshbhratar P.B. , Ramteke D.S. , Effects of sewage wastewater irrigation on soil properties, crop yield and environment, Agric. Water Manag., 103 (2012), pp. 100-104.

[12] Ramana S., Biswas A.K., Kudus S., Saha J.K., and Yadava R.B.R. (2002). Effect of distillery effluent on seed germination in some vegetable crops. Biorecourse Technology 82: 273–275.

[13] Saravanmoorthy M.D., and Ranjitha K.B.D. (2007). Effect of textile waste water on morpho-physiology and yield on two varieties of peanut (Arachis hypogeal L.). Journal of Agricultural Technology, Vol. 3, 335–343.

[14] Darvishi H.H., Manshouri M. and Farahani H.A. (2010). The effect of irrigation by domestic wastewater on soil properties, J. Soil Sci. Environ. Manag. Vol. 1(2) 030-033.

[15] Ricart S. , Rico A.M. , Assessing technical and social driving factors of water reuse in agriculture: a review on risks, regulation and the yuck factor, Agric. Water Manag., 217 (2019), pp. 426-439.

[16] Kalavrouziotis I.K. , Koukoulakis P. , Kostakioti E. , Assessment of metal transfer factor under irrigation with treated municipal wastewater, Agric. Water Manag., 103 (2012), pp. 114-119.

[17] Bhargawa S.K., Handbook of Practical methods for water and air pollution monitoring. New Age International Publication ISBN: 97881-224-24041, 4th Edition

[18] Durvey V.S., Sharma L.L., Saini V.P. and Sharma B.K. (1991) Handbook on the methodology of water quality assessment. Rajasthan Agriculture University, India.

[19] Methods of Sampling and Test (Physical and Chemical) for water & waste water. IS-3025 (1987).

[20] Singh V. (2006). Physico-chemical examination of water, sewage and industrial effluents, Res. J. Chem.and Env. 10(3), 62-66.

[21] American public health association (APHA) Standard Methods for the Examination of Water and Wastewater, 23rd Edition Washington, DC, USA.

[22] Patil S.G., Chonde S.G., Jadhav A.S. and Raut P.D. (2012). Impact of Physico-Chemical Characteristics of Shivaji University lakes on Phytoplankton Communities, Kolhapur, India. Research Journal of Recent Sciences, 1,2, 56-60.

[23] Bryan G.H., Donald A.H., Robert G.S., Jason W.E., Dan M.S. (2007) Managing irrigation water quality for crop production in the pacific northwest. A pacific northwest extension publication, 597-E.

[24] Chauhan R., Chaudhary R., Singh A. and Singh P.K. (2012). Salt Tolerance of Sorghum Bicolour Cultivars during Germination and Seedling Growth. Research Journal of Recent Sciences, 1(3) 1-10.

[25] Richards LA. (1954). Diagnosis and improvement of saline and alkali soils. U.S. Department of Agricultural Hand-book,Vol. 60, Washington D.C., USA, pp. 160.

[26] Wilcox L.V., Blair G.Y., Bower C.A. (1954). Soil Science 77:259-266 No. 216, p 4.

[27] Hasaballah A.F. , Hegazy T.A. , Ibrahim M.S. , Doaa A.E. Water salt toxicity assessment for nile river- damietta branch and evaluating its suitability for irrigation process Int J Eng Res Technol, vol.10 (4) (2021), p. 2021

[28] Bhat M.A., Grewal M.S., Ramprakash, Rajpaul, Wani S.A. and Dar E.A., Assessment of Groundwater Quality for Irrigation Purposes using Chemical Indices, Indian Journal of Ecology (2016) 43 (2): 574-579

[29] Doneen, L.D. (1964) Water Quality for Agriculture. Department of Irrigation, University of California, Davis, 48 p.