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ORIGINAL ARTICLE

Assessment of kitchen wastewater quality for irrigation

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Abstract

In this study, the potential reuse of kitchen wastewater (KWW) in irrigation was analyzed to reduce the present freshwater demand. To know the suitability of KWW for irrigation, the samples were first collected from an educational institute in India and then characterized according to its physical, chemical, and bacteriological properties. The characterized data were then compared with the standard limit for irrigation Food and Agriculture Organization (FAO in Water quality for agriculture. Irrigation and drainage paper 29, M56, 1994) and the US Salinity Laboratory (USSL). Apart from the above irrigation standards, the characterized data were also compared with sodium adsorption ratio (SAR), residual sodium carbonate, sodium percentage (Na%), magnesium hazard (MH), Kelly's ratio (KR), and permeability index to get better clarity. From the characterization, it was found that carbonate, fluoride, chromium, and *Escherichia coli* were absent, whereas parameters like pH, chloride, iron, copper, magnesium, lead, nickel, sodium, calcium, zinc, aluminum, and sodium adsorption ratio were within the permissible limit. The result obtained from the USSL classification system suggested that 30.77% of KWW samples are safe for irrigation. Moreover, its quality was found to be safe for irrigation based on SAR, Na%, KR, and MH. For better decision making of KWW reuse in irrigation, the output of Mamdani fuzzy inference system (MFIS) was compared with the USSL classification system. The overall agreement between USSL and MFIS was found to be 55.6% for KWW.

Keywords Fuzzy logic · Irrigation · Kitchen wastewater

Abbreviations

BDL	Below detection limit
BOD_5	Biochemical oxygen demand
DO	Dissolved oxygen
Ec	Electrical conductivity or salinity hazard
KR	Kelly's ratio
KWW	Kitchen wastewater
me/L	Milliequivalent per liter
mg/L	Milligram per liter
MH	Magnesium hazard
Na%	Sodium percentage
NTU	Nephelometric turbidity units
PI	Permeability index
RSC	Residual sodium carbonate
SAR	Sodium adsorption ratio
TDS	Total dissolved solid
TS	Total solid
TSS	Total suspended solid
$^{\circ}$C	Degree Celsius
%	Percent
µs/cm	Microsiemens per centimeter
µg/L	Microgram per liter
>	Greater than
<	Less than

Introduction

Rapid urbanization and industrialization raise the continuous demand for freshwater supply (Amiri et al. 2014; Parwin et al. 2017). But the limited availability of freshwater resource demands treated wastewater as a substitute for the non-potable use. Wastewater can be considered as both resource and hazard (Hussain et al. 2002). Wastewater is a vital source of essential nutrients and organic matter (Parwin and Paul 2020). According to Shakir et al. (2017), domestic sewage contains a proportion of organic matter and harmful microorganisms such as bacteria, virus, and protozoan, thus causing typhoid, dysentery, diarrhea, and vomiting due to contamination of freshwater. Reuse of wastewater will reduce environmental pollution and supply

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cost and abstain from contaminating freshwater (Al-Jayyousi 2003; Al-Hamaiedeh and Bino 2010). But it consisted of unwanted chemicals and harmful pathogens that can cause both environmental and health risks. The untreated wastewater use in irrigation increases due to water scarcity and inappropriate and insufficient wastewater treatment and disposal and reduces fertilizer costs (Scott et al. 2004; Qadir et al. 2007; Jimenez and Asano 2008). According to Jimenez (2006), wastewater reuse for irrigation can have positive and negative effects. The positive effects are increasing in food production due to nutrients and less investment due to wastewater use, whereas negative effects are health risk via consumption of pathogens and toxic chemicals through plants. According to FAO (1994), irrigation water with excess ionic concentrations can cause plant toxicity and consumption of such causes a serious health hazard. Wastewater causes land salinity and sealing of land and thus causes increased runoff and land erosion (Halliwell et al. 2001; Shakir et al. 2017). Therefore, it is a challenging situation to identify a proper reuse option for agriculture and other sectors with proper utilization of nutrients in it (Raychaudhuri et al. 2014).

Every day, millions of gallons of wastewater are produced from various domestic and industrial activities worldwide (Parwin and Paul 2018, 2019a, b). Black wastewater (including toilet waste) and gray wastewater (excluding toilet waste) are two types of domestic wastewater. The gray wastewater consists of 80% of the total wastewater generation with a maximum contribution (44%) from the kitchen (Vakil et al. 2014). Production of kitchen wastewater (KWW) remains constant irrespective of weather or seasonal variation. The waste produced from kitchen outlet plays a vital role in producing a large volume of organic waste, oil–grease (stick inside the pipe and clogs the pipes), and soap–detergents from educational intuitions, professional organizations, and restaurants (Chandekar and Godboley 2017). In developing countries, KWW with high organic matter and oil and grease was disposed into water bodies without treatment (Naserisafavi and Chu 2017; Rahmat et al. 2017; Gupta and Nath 2018; Katam and Bhattacharyya 2018; Mohamed et al. 2018). Untreated disposal of KWW can cause eutrophication in the water body. Also, the stagnant KWW can become anoxic and create unpleasant odors by the release of ammonia and provide a breeding environment for insect pests. The characteristics of KWW can vary due to the type of cooking and nutritional preferences among households (Mohamed et al. 2013). There is a need for detailed characterization that may help in selecting its optimized treatment method to reduce the impact on soil, crop, and environment.

Agriculture is the major consumer of freshwater in India. Very few research works have been focused on irrigation water from KWW (Ghosh et al. 2010; Khan et al. 2011; Abegunrin et al. 2013; Sivarajah and Gnanavelrajah 2015; Abubakar et al. 2016). As KWW is rich in nutrients, still it remains unnoticed from a quality perspective for irrigation. There are various standards available such as US Salinity Laboratory (USSL) classification system (1954), Wilcox system (1955), and BIS classification system (BIS 11624:1986) to understand the requirement of irrigation water quality. But still, uncertainties arise in the decision making with respect to the usefulness of water particularly when it is wastewater. Few researchers have applied fuzzy logic to solve the complex environmental problem. The concept of fuzzy logic has been applied by several researchers to attain at a simple output (Jowitt and Lumbers 1982; Mirabbasi et al. 2008; Priya 2013; Ostovari et al. 2015; Srinivas and Singh 2017). Adaptive-network-based fuzzy inference system (ANFIS) for irrigation water quality has been applied by Alavi et al. (2010). There is a need for a simple output from the set of complex input variables. Kizhisseri and Mohamed (2016) applied successfully the fuzzy logic concept-based wastewater quality indices for pollution classification. The objective of present study is to characterize the KWW samples to know the hidden characteristics. After obtaining the physicochemical parameters, the reuse possibility of KWW in irrigation needs to be explored. To simplify the decision making process of KWW reuse in irrigation, fuzzy logic approach needs to be applied on the physicochemical parameters.

Materials and methods

Sample collection and data analysis

The KWW samples were collected from a hostel of National Institute of Technology (NIT) Rourkela in India with capacity of more than 1000 students. A total of 13 number of wastewater samples (including both working days and holiday) were collected for characterization. The sampling was done in three shifts, i.e., morning, afternoon, and evening separately. Plastic bottles of 5 L and 2 L capacity were used to collect the wastewater samples. The plastic bottles were thoroughly cleaned by tap water, washed with Millipore water, and again rinsed by KWW sample to avoid any contamination. The collected samples were analyzed for physical, chemical, and bacteriological parameters using different standards, methods, and instruments listed in Table 1. The collected samples were tested in the Environmental Engineering Laboratory of Civil Engineering Department of NIT Rourkela. Metallic concentrations were measured by atomic absorption spectrophotometer (AAS 200, PerkinElmer). Each test conducted triplicates. The estimation of the indices such as sodium adsorption ratio (SAR) using Richards (1954) equation, sodium percentage (Na%), residual sodium carbonate (RSC), magnesium hazard (MH) and permeability

Table 1 Experimental procedure for characterization of kitchen wastewater

Parameters	Standards adopted	Methods used for estimation	Instrument used for estimation
Sampling	IS:3025 (Part 1): 1998	–	–
Color	–	–	Eye observation
Odor	–	–	Olfactory sense
Temperature (°C)	–	–	HQ40D (HACH)
pH	–	–	HQ40D (HACH)
Turbidity (NTU)	–	–	2100 Q (HACH)
Total hardness (mg/L)	IS:3025 (Part 21):2009	EDTA method	–
DO (mg/L)	IS:3025 (Part 38): 2003	Winkler method	–
Chloride (mg/L)	IS:3025 (Part 32): 2003	Argentometric method	–
BOD_5 (mg/L)	IS:3025 (Part 44): 2003	Dilution technique	BOD incubator (REICO)
Fluoride (mg/L)	IS:5182 (Part 13): 2003	Zirconium SPADNS method	UV/Vis spectrometers, PerkinElmer Lambda 35
Fe, Cu, Mg, Pb, Ni, Na, Ca, K, Zn, Cr, Al (mg/L)	IS:3025 (Part 53,42,46,47,54,45,40,45,49,52,55):2003	–	AAS200 PerkinElmer
Arsenic (µg/L)	IS:3025 (Part 37):2003	–	HGA 900-AAS 200
Mercury (µg/L)	IS:3025 (Part 48): 2003	–	MHS15-AAS 200
TS, TDS, TSS (mg/L)	IS:3025 (Part 15,16,17): 2009	Gravimetric method	Hot air oven (REICO)
Sulfate (mg/L)	IS:3025 (Part 24): 2003	Turbidity method	UV/Vis spectrometers, PerkinElmer Lambda 35
Carbonate and bicarbonate (mg/L)	IS:3025 (Part 51): 2001	Titrimetric method	–
Phosphate (mg/L)	4500-P. D APHA (2012)	Stannous chloride method	UV/Vis spectrometers PerkinElmer Lambda 35
E. coli	–	EMB agar method	Laminar air flow (REICO) and incubator (REICO)

index (PI) using Houatmia et al. (2016) equation, and Kelly's ratio (KR) using Kelly (1963) equation was performed.

USSL diagram for irrigation water quality evaluation

USSL diagram is a well-known diagram for classifying irrigation water quality. It was suggested by US Salinity Laboratory Staff (1954). The USSL diagram is a simple scatter plot of salinity hazard (Ec) on *X*-axis against sodium hazard (SAR) on *Y*-axis. The salinity hazard (Ec) is plotted on a log scale. USSL classified water into the following classes (Table 2).

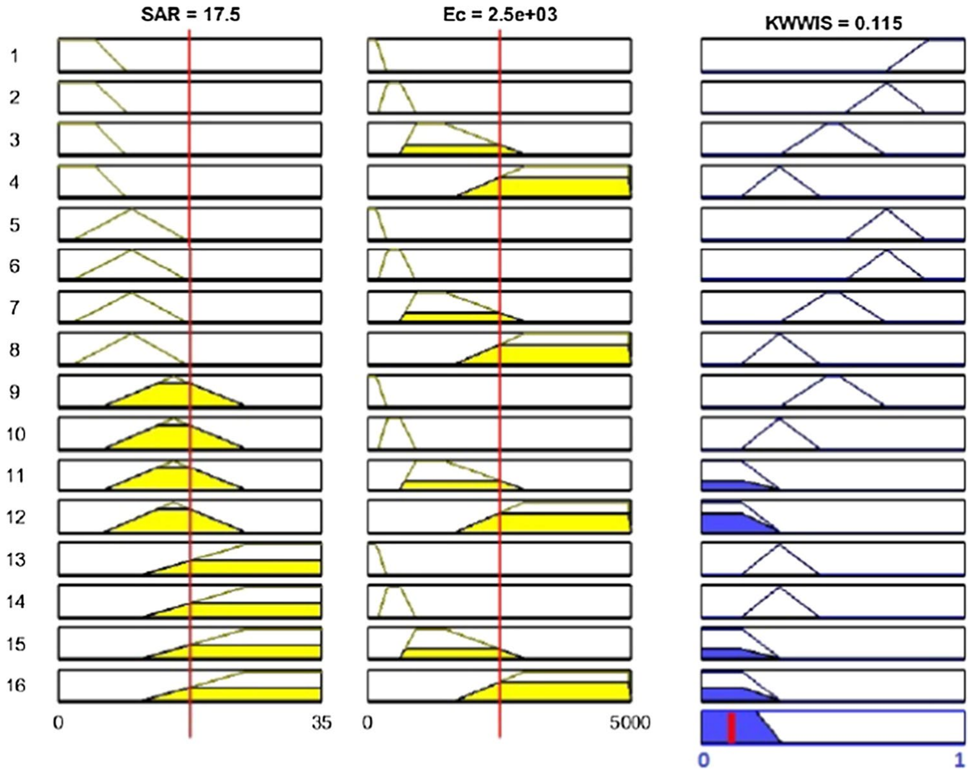
Fuzzy interference system (FIS)

In 1965, Zadeh introduced the concept of the fuzzy set to establish a soft boundary between different levels of subjects where membership is defined by degree. A FIS consists of knowledge base, fuzzifier, inference system (engine), and defuzzifier (Alavi et al. 2010). Researchers (Mirabbasi et al. 2008; Gharibi et al. 2012; Priya 2013; Ostovari et al. 2015) proved fuzzy logic to be a comprehensive tool for the assessment of water quality. In this study, Mamdani fuzzy inference system (MFIS) has been formulated using a fuzzy logic toolbox of MATLAB R2014b software. Membership functions were allocated for two input variables (Ec and SAR), and one output variables of MFIS called kitchen wastewater irrigation score (KWWIS) were used to classify KWW quality. The value for SAR classes, Ec classes and KWWIS classes and rules 16 (4 × 4) were taken from Mirabbasi et al. (2008) and Ostovari et al. (2015). Further, 16 (4 × 4) rules were formulated as shown in Fig. 1.

Table 2 Classification of irrigation water

SAR value (me/L)	Class	Suitability	Ec value (µS/cm)	Class	Suitability
<10	S_1	Very good	<250	C_1	Very good
10–18	S_2	Good	250–750	C_2	Good
18–26	S_3	Satisfactory	750–2250	C_3	Satisfactory
>26	S_4	Bad	>2250	C_4	Bad

Fig. 1 Fuzzy logic interference system (rule viewer)



Results and discussion

In the present study, a detailed characterization of raw KWW collected from educational institute was performed to check its suitability for irrigation use. The bacteriological test showed the absence of *Escherichia coli* (*E. coli*) in KWW samples. The characterized data were then compared with the prescribed limit of Food and Agriculture Organization (FAO 1994). Carbonate, chromium, and fluoride were not found in the sample. The pH values were found within the permissible limit, while TDS and Ec concentration exceeded the standard limit (Table 3). A higher value of TDS is due to washing of plates and utensils that contain sticking food waste. A higher value of TDS can hamper disinfection, clogging of irrigation systems, and deposition (FAO 1994). A significantly higher value of BOD_5 of KWW indicated a large amount of biodegradable organic materials.

According to FAO (1994), irrigation water with excess ionic concentrations can cause plant toxicity. All trace elements are not lethal, but in small concentration, many trace elements are essential for plant growth like Fe, and Zn and excess concentration will cause undesirable accumulations in plant tissue (FAO 1994). Potassium plays an essential role in photosynthesis and metabolism of plants. The study found pH, chloride, iron, copper, magnesium, lead, nickel, sodium, calcium, zinc, aluminum, and sodium adsorption ratio (SAR) are within permissible limit, while bicarbonate, total dissolved solid, conductivity, sulfate, and potassium have exceeded the permissible limit. The extremely hard water consumption for long term might lead to increased probability of cardiovascular disorders and urolithiasis (Houatmia et al. 2016). The range of total hardness in KWW samples varies from 125 to 450 mg/L with an average value of 221.92 mg/L. Sulfate is also an important anion that causes a laxative effect on the human physiological system (Houatmia et al. 2016). Its concentration was obtained from 15.80 to 2206.66 mg/L with a mean value of 1245.59 mg/L that exceeded the limit of irrigation limit (960 mg/L). Chloride value varies from 159.52 to 1985.20 mg/L with an average value of 934.52 mg/L and is found within the acceptable limit (1062 mg/L) of FAO (1994) guideline.

Sridharan and Nathan (2017) analyzed the groundwater quality for irrigation use using SAR, magnesium adsorption ratio (MAR), RSC, Na%, PI, and chlorinity index. Nagaraju et al. (2016) evaluated the groundwater quality for irrigation purpose using salinity hazard, potential salinity, total hardness, total alkalinity, non-carbonate hardness, sodium hazard, and carbonate and bicarbonate hazard. Houatmia et al. (2016) evaluated SAR, Na%, RSC, KR, MH, and PI for groundwater quality for irrigation. The KWW contains essential dissolved minerals like surface water and groundwater. Its suitability for irrigation purpose needs great attention as the crop productivity depends on the quality of irrigation water.

The SAR is used for evaluating the suitability of wastewater for irrigation as it measures alkali/sodium hazard to

Table 3 Summary of KWW quality parameters compared to standard guidelines

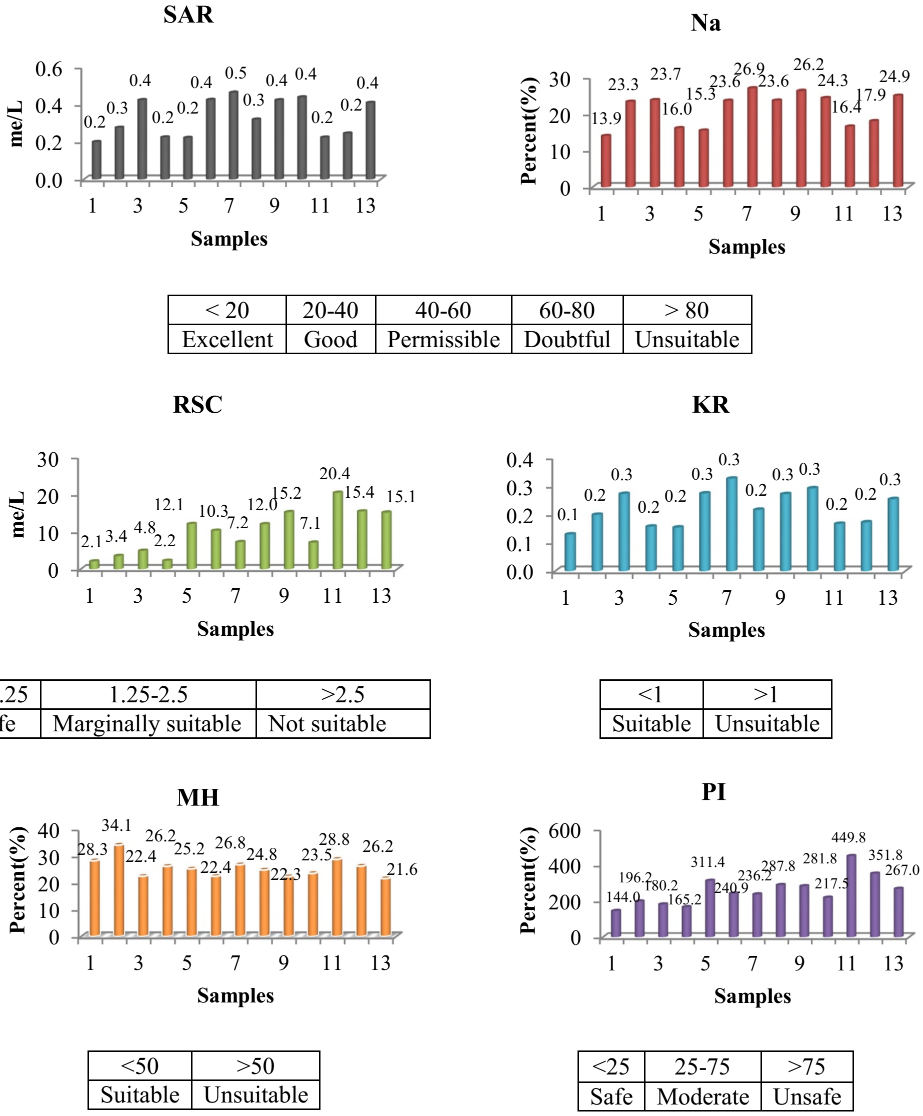
Parameters	Mean*	Range	Usual range in irrigation water FAO (1994)	Discharge into public sewer (IS:2490, 1981)	Discharge into Inland surface waters (IS:2490, 1981)
pH	6.43	5.42–7.2	6.5–8.4	5.5–9	5.5–9
Temperature (^{0} C)	28.65	24.3–34.6	–	45	40
Turbidity (NTU)	1130.38	111–3129	–	–	–
Total hardness (mg/L)	221.92	125–450	–	–	–
Total solid (mg/L)	6005	2394–16215	–	–	–
Total suspended solid (mg/L)	2353	316–7705	–	600	100
Total dissolved solid (mg/L)	3652	936–8510	450–2000	2100	2100
Electrical conductivity (µS/cm)	5450.75	1397.01–12,701.49	700–3000	–	–
Bicarbonate (mg/L)	664.62	200–1300	610	–	–
Carbonate (mg/L)	BDL**	–	3	–	–
Chloride (mg/L)	934.52	159.52–1985.2	1062	1000	1000
Fluoride (mg/L)	BDL**	–	1	15	2
Sulfate (mg/L)	1245.59	15.8–2206.66	960	1000	1000
DO (mg/L)	3.31	1.01–5.62	–	–	–
BOD$_5$ (mg/L)	698.46	240–1340	–	350	30
Iron (mg/L)	0.17	0.04–0.56	5	–	–
Copper (mg/L)	0.01	0.001–0.033	0.2	3	3
Magnesium (mg/L)	3.38	3.14–4.10	60.75	–	–
Lead (mg/L)	0.09	0.011–0.168	5	1	0.1
Nickel (mg/L)	0.02	0.008–0.048	0.2	3	3
Sodium (mg/L)	5.69	3.45–7.61	920	–	–
Calcium (mg/L)	16.58	12.88–20.53	400	–	–
Potassium (mg/L)	2.32	1.12–4.05	2	–	–
Zinc (mg/L)	0.96	0.039–2.048	2	15	5
Chromium (mg/L)	BDL**	–	0.1	2	2
Aluminum (mg/L)	0.07	0.016–0.207	5	–	–
Phosphate (mg/L)	1.29	0.081–3.089	2	–	5
Mercury (µg/L)	10.41	0.177–34.09	–	10	10
Arsenic (µg/L)	2.9	0.536–4.947	100	200	200
SAR(me/L)	0.329	0.19–0.46	15	–	–

*Mean value of $n = 13$, **BDL—below detection limit

crops. In this study, the SAR value ranges from 0.19 to 0.46 (Fig. 2). Excessive sodium concentration in a water sample can have adverse effects in soil permeability (Shakir et al. 2017). The concentration of sodium is a vital parameter in categorizing for its use in irrigation. It affects both soil permeability and infiltration rate. Its excess concentration in irrigation water deteriorates the structure of the soil and thus reduces crop production. High sodium concentration will be adsorbed by clay particles displacing magnesium and calcium ions in soil and thus reduces the soil permeability and finally results in poor internal drainage in soil (Ravikumar and Somashekar 2014).

Water sample containing carbonate plus bicarbonate greater than calcium plus magnesium concentration is called residual sodium carbonate (RSC). The RSC is used to designate the alkalinity hazard of irrigation water for clay soils having high cation exchange capacity. When sodium in water is high in comparison with magnesium and calcium, clay soil swells, undergoes dispersion, and reduces its infiltration capacity. The RSC values vary from 2.06 to 20.40 me/L. From the observed results, only two of the KWW samples are categorized as marginally suitable for agricultural use.

The KR value > 1 indicates excess sodium concentration in water. So, water with KR < 1 is suitable for irrigation, while those with a ratio > 1 are unsuitable. The KR is used to estimate the harmful effect of sodium on irrigation water quality. It ranges from 0.12 to 0.32. All wastewater samples are suitable for irrigation use, which have a KR



< 20	20-40	40-60	60-80	> 80
Excellent	Good	Permissible	Doubtful	Unsuitable

<1.25	1.25-2.5	>2.5
Safe	Marginally suitable	Not suitable

<1	>1
Suitable	Unsuitable

<50	>50
Suitable	Unsuitable

<25	25-75	>75
Safe	Moderate	Unsafe

Fig. 2 Variation of SAR, Na, RSC, KR, MH, PI among KWW samples

value < 1 and are considered as suitable for irrigation since they contain less level of Na^+.

The MH suggested for irrigation purpose depends on the concentration of calcium and magnesium which sustain a state of equilibrium in water (Houatmia et al. 2016). Excess concentration of magnesium in water during equilibrium will undesirably affect soil quality, resulting in a decrease in crop production (Kumar et al. 2007). In the analyzed wastewater samples, the MH values vary from 21.58 to 34.12. All analyzed KWW samples, MH values < 50 and hence are considered as harmless and suitable for irrigation use. The permeability of the soil is also affected by long-term use of irrigation water as it is influenced by calcium, sodium, magnesium, and bicarbonate content of the soil. The PI can help in evaluating the soil permeability that is affected by long-term use of irrigation water. It is found that PI values range from 143.97 to 449.79 which considered as unsuitable for irrigation use.

The SAR value of KWW samples ranges from 0.19 to 0.46 milliequivalent per liter (me/L) with an average value of 0.33 me/L, while Ec ranges from 1397.01 to 12701.49 µS/cm with an average value of 5450.75 µS/cm. High conductivity showed the presence of a higher concentration of dissolved salts and heavy metals due to washing of plates and utensils. From USSL classification, 30.77% of KWW samples fall in the S_1C_3 category. This category of wastewater may be used for irrigation in all types of soil with a slight danger of exchangeable sodium (Ostovari et al. 2015). Remaining wastewater quality (69.23%) categorizes into the S_1C_4 category. Uncertainties prevail in USSL system in checking the final suitability of irrigation water as it does not mention anything about suitability for a combination of USSL class.

The fuzzy surface is a graphical representation that can be used to check the influence of SAR and Ec with the output score of KWW quality (Fig. 3). A nonlinear relationship has been observed between KWWIS and SAR, and Ec. At

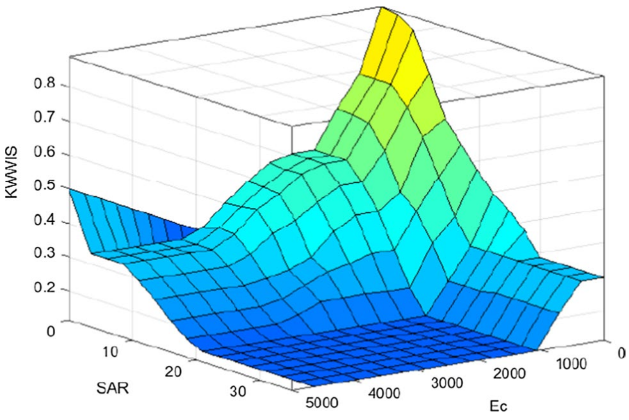


Fig. 3 Fuzzy surface: Ec and SAR versus KWWIS

higher values of SAR and Ec, the relationship with KWWIS becomes linear and flat, and the score tends to zero, considering "very bad" water quality. To have "very good" water for irrigation, score must be greater than 0.7; it can only be possible when SAR value < 10 me/L and Ec value < 250 µS/cm. Mirabbasi et al. (2008) and Ostovari et al. (2015) obtained a similar fuzzy surface with identical rules. The SAR values were always found less than 10 me/L, whereas Ec was found exceeding 250 µS/cm. The output of MFIS showed 92.31% medium and 7.69% bad class of sample category. In the present study, overall agreement between USSL and MFIS was 55.6%, whereas Ostovari et al. (2015) and Mirabbasi et al. (2008) found 92.8% and 84%, respectively. Ostovari et al. (2015) suggested with the rise of SAR and Ec concentration, USSL diagram failed to provide the correct classification of irrigation quality of groundwater that can be used for irrigation. Mirabbasi et al. (2008) revealed that in groundwater samples, maximum agreement was between USSL diagram and MFIS method with low SAR and Ec values.

Impacts of raw kitchen wastewater on the environment

The KWW contains higher concentration of various parameters as compared to irrigation standards (FAO 1994) and discharge to inland surface waters and discharge to public sewer (IS: 2490 (Part I) 1981) as shown in Table 3. Therefore, proper treatment is required before its discharge to avoid any environmental pollution. In developing countries like India, there is no separate drainage system for KWW. The pollutant present in KWW mixes with a common drain which finally discharges to water bodies like river, canals, and ponds. The presence of excess nutrients stimulates the growth of algae (eutrophication) which then decomposes, depletes oxygen level, and harms aquatic life (Raychaudhuri et al. 2014). Arsenic and mercury are not degraded easily and accumulate in fish tissues and enter the food chain. On consuming contaminated fish, human being faces serious health issues like the central nervous system, neurological impairment, kidney problem, etc. Higher phosphorus levels in the water body such as rivers cause eutrophication and depletion of dissolved oxygen level (Davie 2003).

Due to rich in nutrient, KWW can be a good option to counter the present freshwater stress for irrigation. Without any treatment of KWW, if it uses for irrigation, then it has an adverse effect both on crop and land. Higher TDS concentration in KWW hampers the efficiency of irrigation by clogging of irrigation systems and deposits layer on the inner side of pipes thus reducing the flow of water. High concentration of soluble salts like bicarbonate and sulfate creates white scale formation on leaves or fruit when sprinklers are used. The deposit on leaves or fruit reduces the marketability of fruit and foliage. Potassium also has the deleterious effect on soil hydraulic conductivity property apart from flora and fauna (Smith et al. 2014). In rural areas, KWW disposes of either in a small pit or drain on an open surface. The turbidity of KWW is high; it percolates slowly through the different layers of soil strata. After a certain period, the upper surface of the soil will be choked by tiny particles present in KWW. The stagnant KWW invites many diseases caused by mosquitoes like malaria, filariasis, and dengue. The wastewater contamination is more in shallow groundwater condition particularly in rainy season, causing diarrhea diseases.

In an urban area, most of the time KWW contaminates the freshwater by leakage in the water supply or groundwater contamination in rural areas due to its low groundwater level below the surface. Supply water pipe should be in good condition so that there should not be any cross-connection or leakage between freshwater and effluent (Drechsel et al. 2010). If KWW accidentally contaminates freshwater supply, then excess concentration of sulfate will cause laxative effect and gastrointestinal irritation, aluminum (Alzheimer's disease, neurological disorders,), copper (mucosal irritation, liver damage, depression, and renal damage), and zinc (gastrointestinal, abdominal pain, dehydration, nausea, and dizziness) (Raychaudhuri et al. 2014). A higher TDS concentration causes a dangerous effect to human health such as paralysis of the tongue, lips, and face, irritability, and dizziness (Gupta et al. 2017). In the human body, the reaction of nitrite and iron in red blood cell creates methemoglobin which stops oxygen level and thus causes a disease called blue baby syndrome. A higher value of turbidity reduces filter runs which cause harmful microorganisms to be more dangerous to human life. A higher phosphate concentration causes muscle damage, breathing problem, and kidney failure (Nyamangara et al. 2013; Gupta et al. 2017).

Conclusion

KWW with zero value can be considered as a valuable resource after exploring the hidden characteristics contained in it. In this study, to identify the possibilities for reusing of KWW in irrigation, KWW samples were examined in the laboratory. It was found that parameters like pH, chloride, iron, copper, magnesium, lead, nickel, sodium, calcium, zinc, aluminum, and SAR are within permissible limit, while bicarbonate, total dissolved solid, conductivity, sulfate, and potassium have exceeded the permissible limit according to FAO. The result obtained from the USSL classification system suggested that 30.77% of KWW samples are safe for irrigation. The quality of KWW was observed to be safe for irrigation based on SAR, Na%, KR, and MH indexes. But, for RSC and PI indexes, the KWW needs to be treated for sustainable reuse. After comparing USSL with MFIS, the overall agreement was found to be 55.6%. From the obtained results, it was found KWW treatment is required to reuse in irrigation. To find a low-cost technique for KWW treatment is the future scope.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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