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REVIEW

Urban Rejected Water Reuse in Agriculture for Irrigation in Major Cities of India: A Synoptic Review

Shivarajappa[1] L. Surinaidu[2*] Mohd. Hussain[3] K. Aruna Kumari[2] M.J. Nandan[2]

1.Jawaharlal Nehru Technological University, Hyderabad, India
2.CSIR-National Geophysical Research Institute, Hyderabad, India
3.Civil Engineering Department, Gokaraju Rangaraju Institute of Engineering & Technology, Hyderabad, India

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ABSTRACT

Indiscriminate and rapid urbanization without sufficient infrastructure to manage huge domestic sewage (urban rejected water) generated by urban centers posing serious threats to different ecosystems in many places across the world. On the other hand, the downstream of urban centers facing an acute shortage of water for irrigation. In recent years reuse of urban waste water is being increased in many countries including India irrespective of adverse impacts on other ecosystems. The present study has provided a synoptic review on urban rejected water reuse for irrigation in the major cities of India with a special focus on banks of the Musi river basin in South India where huge wastewater irrigation is being practiced in the world in comparison with global waste water irrigation practices. In all the cases major contaminants namely fecal coliform, nitrates, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Dissolved Oxygen (DO) are found in water and with increased soil and groundwater salinity on long term use. The review indicated that there a large scope to intensify the irrigation with proper treatment of wastewater. The study also suggested to understand the impacts of rejected water reuse impact on soil-water-food chain and also emphasizes the need for the establishment of sufficient ETPs to minimize the adverse impacts and also to protect hydro-agro ecosystems.

1. Introduction

In recent years, wastewater irrigation is being increased especially in the case of destitute countries where farmers economically interesting peri-urban interfaces and hardly able to find unpolluted surface water sources [1,2,3]. Water reuse could be an option in water-scares regions in the world for supplying reliable water for different applications where high-quality water is not required. Consequently, freeing up limited potable water sources conserving the freshwater resources, while reducing the effluent discharges into the receiving waters [4]. The land application of wastewater for disposal is an indispensable solution and agricultural use was utilized first in European cities and later in USA [5]. In recent years, interest in water reuse is growing steadily not only in relatively water deficient countries (e.g. Greece, Portugal), but also in highly populated Northern European States such as Belgium, France,

**Corresponding Author:*
L. Surinaidu,
CSIR-National Geophysical Research Institute, Hyderabad, India;
Email: suryangri@gmail.com

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U.K and Germany, as well as in tourist coastal areas and islands [6]. Currently, water reclamation and reuse projects were being planned and implemented all over the world. Recycled water is presently used for almost any purpose including potable use [5]. It is projected that 700 million cubic meters per year (Mm^3 /yr.) of treated wastewater were directly reclaimed and used as an alternative source of water in Europe in 2004 [7]. In many countries, the reuse of (usually treated) wastewater is an important strategy to cope with fresh water crises [8]. Demonstrated case studies on recycled domestic wastewater in various countries including Australia, Asia, United States, India, Latin America, Europe, the Middle East, and Africa is already available [9,10,11]. These studies may be the best examples for planning the future reuse of urban rejected water in various parts of the world [12]. Water scarcity problems are common in the arid and semiarid regions, which include the highly populated regions of Asia particularly India, China, the United States, and most of the Middle East. Wastewater reuse is an alternative to increase available water supplies [13]. Land application of wastewater is widespread phenomena, having both beneficial or detrimental effects depending on the geographic region and the type of wastewater produced and represents around 10% of the total irrigated area worldwide, although varying widely at local levels [14]. Reuse of wastewater in agriculture can be a sustainable solution encouraged by various countries to face water scarcity worldwide with robust management practices, such as the application of suitable treatment technologies and irrigation practices that can be beneficial while minimizing risks [15].

On the other hand, untreated wastewater irrigation is associated with numerous environmental problems including soil salinization, reduced soil hydraulic conductivity, reduced crop yield, and surface/groundwater resources contamination, the wild life, and the food-chain and eventually the prevalence of diseases [1,16,17,18]. Further, reuse of wastewater for agriculture causing microbial contamination in the edible parts of vegetables and accumulation of heavy metals, and Pharmaceuticals presence in the wastewater are a growing global concern [19]. Though treated wastewater is augmenting irrigation water supplies, there has been great concern about associated health risks and environmental impacts [20]. India is one of the fastest developing countries with an alarming rate of rise in an urban population facing severe water scarcity in terms of its quality and quantity. At the same time urban centers producing huge amounts of domestic sewage that would have great potential for reuse to reduce some of the water stress for irrigation that can produce an agriculture-based economy in peri-urban areas. The present study has reviewed domestic waste water production and its reuse in the ten major urban cities of India and its consequences on the environmental health of different ecosystems with a special focus on Musi river basin where the highest domestic sewage is being reused for irrigation in Hyderabad, India.

2. Study Area and Methodology

In the present study, we have provided a synoptic review of existing wastewater reuse practices in different countries in comparison with India based on published literature. All relevant literature is properly cited and provided as a list of references. It is also provided the wastewater reuse impacts on different ecosystems that include surface water, soils, groundwater, and corps in the major cities of India with a major emphasis on Hyderabad city situated on the banks of Musi river in South India. The water source for Hyderabad city met from different sources from external river basins. The Hyderabad Metropolitan Water Supply & Sewerage Board (HMWS&SB) is responsible for the supply of freshwater and management of sewage water. HMWS&SB is drawing 172 million gallons a day (mgd) of Godavari water at the Yellampally barrage and 270 mgd of Krishna water from Nagarjuna Sagar reservoir, combined with a total quantity of 442 mgd (equivalent to 1675 MLD) of fresh water is supplied for the population of Hyderabad city in the state of Telangana, India [21]. The urban rejected water (sewage) from Hyderabad flows to the Musi river. In 2020, it was reported that nearly 700 MLD of the wastewater (i.e. 40%) has been reused out of total wastewater produced from the both domestic and industrial origin in and around Hyderabad city (Figure 1). About 10,000 ha, of paddy rice crop (Oryza sativa) and 2100 ha, of paragrass (Brachiaria mutica) are being irrigated with wastewater in downstream of Hyderabad. Paragrass is perennial crop and grows well using the nutrients carried in the stream under warm, moist and fertile conditions. Availability of wastewater enables farmers to harvest Para grass throughout the year or to produce two rice crops kharif and rabi annually for their livelihood[22]. In the present, we also have collected water, soil and groundwater samples in the Musi catchment. The daily water requirement and produced waste water are estimated by using the following formulae.

Quantity of water required daily = [Total Population] X [liters per capita per day (lpcd)] (MLD) -Equation (1)

Quantity of wastewater generated daily = 80% of the fresh water used (MLD) - Equation (2)

Cost of the Treatment Plant (STP) in lakhs INR = Quantity of wastewater in MLD X 80 lakhs INR - Equation (3). Estimated Cost for the Treatment of one million liters (1 MLD) of wastewater = 80 Lakhs [23]. The popula-

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tion data are obtained from world statistical data [24].

3. Global Wastewater Reuse Practices

Various cities in India and China are reusing urban sewage water after partial or full treatment for various applications of non-potable use such as farm forestry, peri-urban irrigation, horticulture, toilet flushing, industrial use for cooling towers, fish culture, producing vermicompost, gardening including parks, resorts and golf course. China treats 95% of total wastewater discharged by municipal wastewater treatment plants (WWTPs), around 4.98 giga cubic meter. The treatment process involves primary, secondary and tertiary treatment in both countries, in addition to this China uses novel wastewater treatment technology, such as Anaerobic Ammonia Oxidation to treat the wastewater [25,26]. Singapore reuses urban rejected water after treatment for indirect potable water called NEWater. In this process treated sewage water combines with nutrient-rich reservoir water, purified again, and filled into bottles. Today, around five percent of tap water in Singapore comes from NEWater [27]. Singapore's NEWater pre-treatment includes removal of debris, uses primary and secondary sedimentation tanks and bio-reactors, ultrafiltration (UF), reverse osmosis (RO), and UV disinfection [28]. In various parts of USA, wastewater is reused for irrigation (both agricultural and landscape), recharge of aquifers, seawater barriers, industrial applications, dual-distribution systems for toilet flushing, residential irrigation, golf course irrigation, groundwater recharge or indirect potable reuse, wetlands, and other urban uses. In California, microfiltration, reverse osmosis, and ultraviolet irradiation (UV) are the treatments prior to groundwater recharge [29]. Japan reuses around 215 million cubic meter per year recycled urban sewage water for different environmental applications including snow melting, irrigation, landscapes, direct supply industrial use, industrial water system. The sewage water is treated with highly advanced water treatment using a membrane bioreactor system in Japan. Tokyo reuses to meet environmental flow requirements of rivers after treatment with UV method, recreational use applies RO method, and toilet flushing treated with biological filtration and ozone followed by membrane treatment method and clean or wash water with ozone treatment [30]. In Australia, the Sydney suburb of Rouse Hill wastewater treatment plant treating 4.4 million liters per day of wastewater for reuse, with coagulation, flocculation, filtration, and disinfection, initially including ozonation but subsequently with UV irradiation and super-chlorination treatment techniques [31]. Windhoek, situated in the center of Namibia, South Africa uses recycled water for drinking water purposes due to a lack of surface and groundwater supplies, here wastewater treatment includes primary settling and anaerobic digestion with drying beds. To produce high-quality water for both drinking and irrigation biofilter system was integrated into the activated sludge system [32]. Reuse of urban rejected water without proper treatment may have adverse negative impacts on human health and the environment. To meet quality criteria to minimize the risks, US Environmental Protection Agency (EPA) has set the guidelines for wastewater reuse. The main purpose of the EPA Guidelines for water reuse is to provide supporting information for the benefit of regulatory agencies to implement water reclamation for non-potable use of urban, industrial, and agricultural purpose and augmentation of potable water supplies through indirect reuse without any major adverse health and environmental risks [33,34]. The comparative reuse water quality standards of various countries are shown in Table 1, which could be useful for regulatory authorities elsewhere.

4. Results and Discussion

Direct use of urban rejected water reuse is restricted in recent decades to protect public health and the environment. Many countries are not able to afford for proper treatment of waste water due to heavy investments involved in the treatment depending on the volume of the wastewater produced and the number of treatment stages [35]. Irrigation with reclaimed water has shown a favorable response on crop growth and yielded acceptable product qualities however, the reuse of improperly treated waste water in irrigation may cause environmental deterioration, pollution in the irrigated area, and groundwater contamination, decrease in soil quality, and posed risks to human health [36]. Wastewater application is associated with an increased risk of various infectious diseases due to high pathogen levels and many other contaminants concentrations found in wastewater [22]. Despite the negative impacts of waste water reuse, Florida and California of USA is efficiently utilizing the reclaimed water for the past 50 years by imposing restrictions more stringent than World Health Organization (WHO) guidelines [9]. All developed countries are following stringent regulations while reusing urban wastewater. However, there are no stringent regulations or comprehensive policies on wastewater reuse exist in India. Due to this limitation and without separate wastewater reuse policies, it is estimated that 75 percent of the total wastewater produced in India discharged without treatment [37].

As the overall demand for water increases with a rise in population there will be a definite increase in the quantity of wastewater produced and its overall pollution load. In

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Table 1. Irrigation water quality standards for wastewater reuse in agriculture used by various countries

S. No.	Parameters	India	South Korea	WHO	US EPA	Cyprus	France	Greece	Italy	Israel	Spain	Saudi Arabia
1	**Fecal coliform (count/100 ml)**	≤ 500 (MPN)	≤ 200 (MPN)	≤ 10000 (cfu)	≤ 200 (cfu)	≤ 1000 (MPN)	≤ 10000 (cfu)	≤ 200 (cfu)	≤ 100 (cfu)	≤ 10 (cfu)	≤ 1000 (cfu)	
2	**Turbidity (NTU)**	≤ 5	≤ 5		≤ 2			≤ 2			≤ 10	≤ 5
3	**Suspended Solids (mg/L)**				≤ 30	≤ 45	≤ 15	≤ 35	≤ 10	≤ 10	≤ 35	≤ 10
4	**BOD mg/L**	≤ 30	≤ 8		≤ 30	≤ 30		≤ 25	≤ 20	≤ 10		≤ 10
5	**COD mg/L**	≤ 100			≤ 100		≤ 60		≤ 100	≤ 100		≤ 50
6	**Odor**	Un-objectionable	Pleasant									
7	**Total Nitrogen (mg/L)**				2 - 6				≤ 15	≤ 25		
8	**Total phosphorus, mg/L**				≤ 1				≤ 2	≤ 5		
9	**Intestinal nematodes (count/L)**			≤ 1	≤ 1						≤ 1 (/ 10L)	
10	**pH**	6 - 8.5	5.8 -8.5		6 - 9				6 - 9.5	6 - 9.5		6 - 8.4
11	**EC (μs/cm)**	≤ 2250	≤ 2000		≤ 1500				≤ 3000	≤ 1400		
12	**DO**	≥ 6			≥ 7.1							

(Source; Hanseok Jeong et al., 2016 and Al-Jasser, 2011)

Table 2. Current and projected wastewater generation and treatment capacities with treatment costs

	Present (Year-2021)					Projected (Year-2031)				
City Name	Present Population in 2021 (Million)	Present water supply (MLD)	Present wastewater generation in 2021 (MLD)	Present treatment required in 2021 (MLD)	Existing treatment capacity (MLD)	Projected Population in 2031 (Million)	Projected wastewater generation in 2031 (MLD)	Future additional treatment capacity in 2031 (MLD)	Present treatment cost in 2021 (INR-Million)	Future additional treatment cost in 2031 (INR-Million)
Hyderabad (Telangana)	10.27	2068	1700	930	770	13.00	1950	250	7440	2000
Vellore (Tamil Nadu)	0.58	86	69	31	38	0.71	107	38	248	304
Bangalore (Karnataka)	12.77	2250	1800	1080	720	16.59	2000	200	8640	1600
Delhi	31.18	4500	3600	885	2715	39.81	4780	1180	7080	9440
Panipat (Haryana State)	0.56	95	77	7	70	0.70	91	14	56	112
Phagwara (Punjab)	0.12	30	24	7	14	0.14	30	6	56	48
NEERI, Nagpur (Maharashtra)	2.94	680	524	44	480	3.61	605	81	352	648
Pune (Maharashtra)	6.81	1350	1080	620	460	8.63	1295	215	4960	1720
Kolkata (West Bengal)	14.97	2246	1796	793	1003	17.97	2156	360	6344	2880
Chennai (Tamil Nadu)	11.24	1985	1588	861	727	14.12	1938	350	6888	2800
Mumbai (Maharashtra)	20.67	3750	3000	1002	1998	25.12	3530	550	8016	4400

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India, various cities practicing wastewater irrigation and it is important to understand their impacts on different ecosystems. The present and projected population, water requirement, and wastewater generation for major Indian cities are provided in Table 2. The table shows that produced wastewater is going to increase that demands more investments.

These cities using untreated or partly treated wastewater for irrigation. Many studies have been carried out to assess the impact of wastewater reuse on soil, water, and crop ecosystem. The summarized results for major Indian cities are provided in Table 3.

The complied results indicated sewage effluents and groundwater in Delhi, India shows there was no significant difference in pH of sewage effluent and groundwater [38]. However, significant seasonal variation in pH of sewage effluent is observed. The electrical conductivity (EC) of groundwater was higher as compared to that of sewage effluents.

This may be ascribed to the leaching of salts from soil sodium due to the long-term use of sewage effluents that enriched groundwater with salts. There were no significant differences between metal and metalloid content in sewage and groundwater indicating that the groundwater in this area was contaminated with sewage irrigation [38,39]. The study in Nagpur city reported that the organic carbon values in sewage water irrigation are higher than well water indicating sewage irrigation aids to improve in fertility status of soil [40]. It is reported that a significant improvement on fertility status of soil for available N, P and K. This indicates that sewage water irrigation provides the essential nutrients to the crops and significant improvement in fertility status of soil with respect to micronutrient. The metals Fe, Mn, Zn, Cu, Pb, Ni, and Cd after harvest were found to be slightly higher than that of well water however, they are within the desirable limits compared to pure sewage water. The use of sewage increased crop production compared to irrigation with well water. On the other hand, the indiscriminate long-term use of sewage effluent for crop production resulted in the con-

Table 3. Chemical concentrations in wasterwater irrigated areas of different cities in India

City Name	Samples	N	P	K	S	Zn	Cu	Fe	Mn	Ni	pb	Cd	Cr	As
KES DELHI (Ramu et al., 2016)	Sewage effluents (mg/L)	47.1	3.41	18.5	56.8	6.29	3.58	421	31.8	7.59	0.16	0	1.01	8.67
	Ground water (mg/L)	36.7	0.67	6.25	37.8	3.65	2.95	392	16.5	3.46	0.01	0.02	1.39	7.96
Nagpur (India) (Singh et al., 2012)	Sewage water (mg/L)			0.31		2	2.4	83	22	4.1	7.5	2.1		
	Well water (mg/L)			0.18		2	1.2	18	16	1.5	4.5	0.6		
Panipat City (India) (Pawan et al., 2013)	Effluent (mg/L)					0.242	0.326	0.356	0.17	0.03	0.404	0.01		
	Ground water (mg/L)					0.153	0.384	2.303	0.4	0.1	1.284	0.01		
	Soil (μg/g)					13.13	26.63	44.08	9.9	7.96	42.36	1.93		
Bengaluru Soils (Jayadev and Puttaih, 2012)	Soil sample Station -1 (mg/kg)					37.2	5.4	126	30.6	4.8	7.2		1.2	
	Soil sample Station -2 (mg/kg)					30.6	3	150	60	3	7.8		3	
	Soil sample Station -3 (mg/kg)					15.6	0.6	186	72	5.4	9		2.4	
	Soil sample Station -4 (mg/kg)					18	9	180	28.8	6	5.4		0.6	
	Soil sample Station -5 (mg/kg)					21	21.6	199.2	30.6	19.2	1.2		24	

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centration build-up that may become phytotoxic that may cause clinical problems both to animals and human beings consuming these metal-rich plants in India [40]. Groundwater in Panipat showed that the concentrations of metals like Pb and Fe in excess quantity (0.74 and 2.76 mg /L) [41]. In the Panipat industrial area, metals from surface water may percolate down into shallow aquifers via soil profile. The leaching effect of heavy metals results in the excess amount of these metals in the groundwater. It is reported that the average concentrations of heavy metals, i.e. Cadmium, Copper, Iron, Manganese, Nickel, Lead, and Zinc in the surface soil were 1.927, 26.633, 44.078, 9.90, 7.96, 42.358, and 13.127 (mg/g) respectively, among these Fe, Pb, Cu values found were at a high level due to their cumulative and adsorptive properties in the soil after repeated irrigation by contaminated groundwater. Cadmium and Zinc were found minimum due to their weak adsorptive nature in soil.

In Punjab, the reuse of wastewater impact on soil and groundwater is extensively studied by [42]. The chemical concentration in soils was analyzed with the application of groundwater and sewage water. Sewage application on soil after 10, 15 and 20 days was analyzed. They reported that both opportunities and problems exist in using sewage water for irrigation. Wastewater irrigation helps in water conservation and nutrient recycling, hence, reducing the demands of freshwater. But variation in pH of soils is observed when compared to groundwater irrigations with soil irrigated with the sewage water. The value of Nitrogen (N) and Phosphorus (P) is increasing till day 10 but decreases thereafter and the value of Potassium (K) is increasing till day 15 and decreases thereafter. Orgonic corban (OC) is decreased till day 10 but increases from day 10 to day 15 and gradually decreases till day 20. The use of wastewater is proved to be beneficial for 10 to 15 days in the selected crops. The application of domestic wastewater increased the crop yield compared to irrigation with groundwater. In another case study carried out in Vrishabhavathi River, Bangalore, Karnataka, revealed that, the concentration of heavy metals in soil was in the order of Fe>Mn>Zn>Cu>Ni>Cr>Pb. Cadmium was below the detectable limit [43]. Cadmium was below detectable level in all vegetable samples. In the water and sediment samples from four different stations of Adyar River at Tamilnadu were collected [44]. The concentration of heavy metals in river water and river sediments was determined and results indicated that the concentration of heavy metals found in river water was lower than the sediment samples of River Adyar that are within drinking water standards of [45]. The wastewater samples were collected at two locations in different periods in an industrial area situated in the southwest of Vellore district, Tamilnadu, India [46]. During four seasons for analysis. The results revealed that the parameters are within the allowable limit for agricultural usage. Therefore, it affects the surface water, groundwater, and soil surrounding area. However, bore wells located close to the industrial area show TDS, alkalinity, sodium, calci-

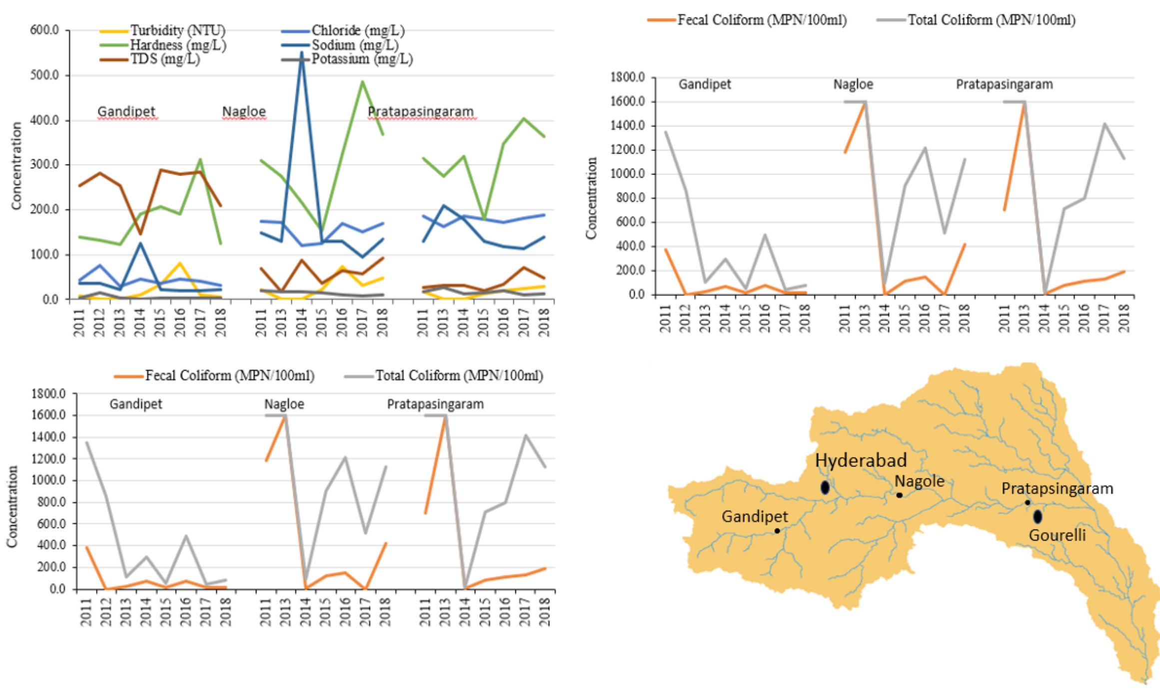

Figure 1. Different chemical concentrations in surface water from 2011 to 2018 at three different locations in Musi river basin (Data Source: TSPCB)

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um, potassium, chloride sulfate, and Hardness exceeds the permissible limit for drinking purposes by [45]. The following sections are explained the impact wastewater reuse on soil, water, and crops in the Musi catchment in detail.

4.1 Wastewater Impact on Surface Water Quality

The time series analysis data of physico-chemical parameters of surface water from 2011 to 2018 in the upstream named as Gandipet (Osmansagar lake), Hyderabad which is fresh water source that supplies part of Hyderabad city drinking water need indicates the DO, COD, BOD, Nitrate-N, Phosphate, Boron, fluoride, sodium absorption ratio values are within drinking water standards [45] and irrigation water standards prescribed by Indian Standards (IS) [47]. Hardness values in 2014, 2015 and 2016 exceed the permissible limit for irrigation, fecal coliform, and total coliform value found in 2011, 2012 exceeded the permissible that could be due to domestic waste water flows with insufficient fresh water for dilution (Figure 1).

When it goes downstream at Nagole and Pratapsingaram, the analysis results revealed that total coliform and fecal coliform are very high concentrations that show the high mixing of domestic water with surface water. Chloride, Hardness, Sodium, Total Suspended solids (TSS), Potassium values also more than the permissible limit of BIS (2012) irrigation standard downstream of the area. This indicates the strong sewage comprising of suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms. The dissolved oxygen (DO) values less than the minimum prescribed value of BIS (2012) irrigation standards are undesirable and indicates that low oxygen level available for living organisms (Figure 2). (DO) primarily results from excessive algae growth caused by phosphorus and low DO value in the water system causes a threat to aquatic life. Fecal Coliform and total coliform values found in 2011, 2013, and 2018 exceeded the permissible limit. Biochemical oxygen demand (BOD) values found in 2011,2012,2013,2015,2016 and 2017 exceed the permissible limits of BIS (2012) irrigation standard (Figure 1). The sodium absorption ratio (SAR) value found in 2011 exceeds the permissible limit of BIS (2012) irrigation standard.

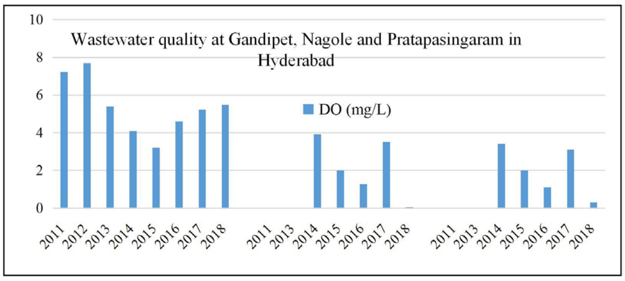

Figure 2. Dissolved oxygen concentration at three different locations in Musi

(Source: TSPCB)

4.2 Wastewater Impact on Groundwater Quality

In the Musi river basin, huge groundwater is also being pumped out that is more than natural recharge, as

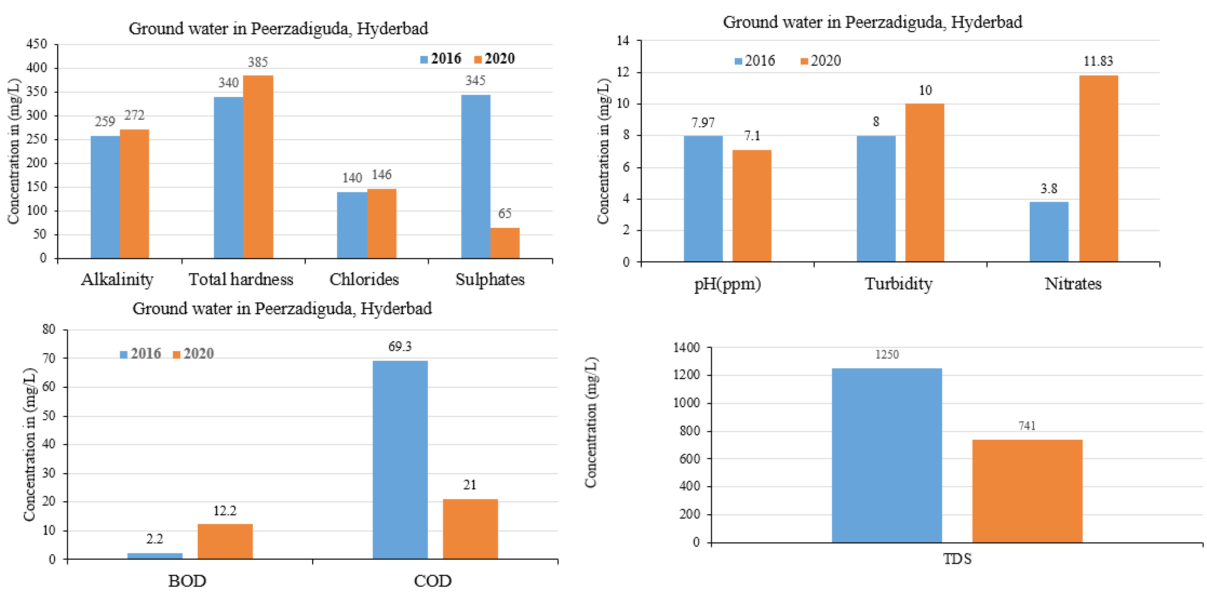

Figure 3. Chemical concentration in groundwater in Peerzadiguda village along the Musi

(Source: Sujatha, 2016 and Sujatha, 2020)

result groundwater wells are less productive or dried out. Hence, to supply the irrigation needs of the area, farmers are using wastewater in downstream. As presented in the previous section salinity of surface water is being increased over the years. When high saline water is applied with other pollution loads on the ground-surface, soil and groundwater quality may have deteriorated on long-term use. The water quality results for two years 2016 and 2020 of groundwater Peeradiguda are shown high TDS and Sulphate values which are more than drinking water standards of WHO, 2011 (Figure 3). The BOD value in the year 2020 exceeds the acceptable limit. The higher values indicate that the leaching of the Musi river water into the groundwater storage which receives heavy loads of domestic and industrial waste produced in Hyderabad. Sulfate value in the year 2016 exceeds the acceptable limit [48,49]. Sujatha has reported the high inorganic matter and high turbidity in groundwater samples which are commercial, industrial or domestic wastewater, and alkalinity and sulfate it is due to discharge of domestic sewage which contains detergents, sulfates induces the formation of sulphuric acid, Hydrogen sulfate [48]. A high level of sodium and salinity hazard values affects all types of vegetables and paddy rice grown in this area. Sodium and chloride present in canal water posed toxicity problems to plants [50].

4.3 Wastewater Impact on Soil Quality

Soil and fodder crop samples were collected for two

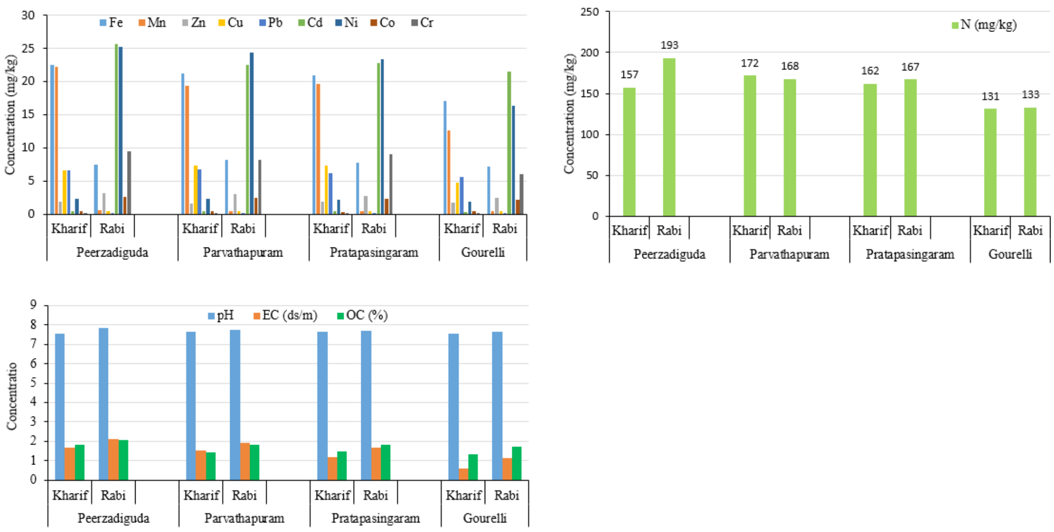

Figure 4. Chemical concentrations in soil in four different villages along the Musi

(Source: Raju et al., 2020).

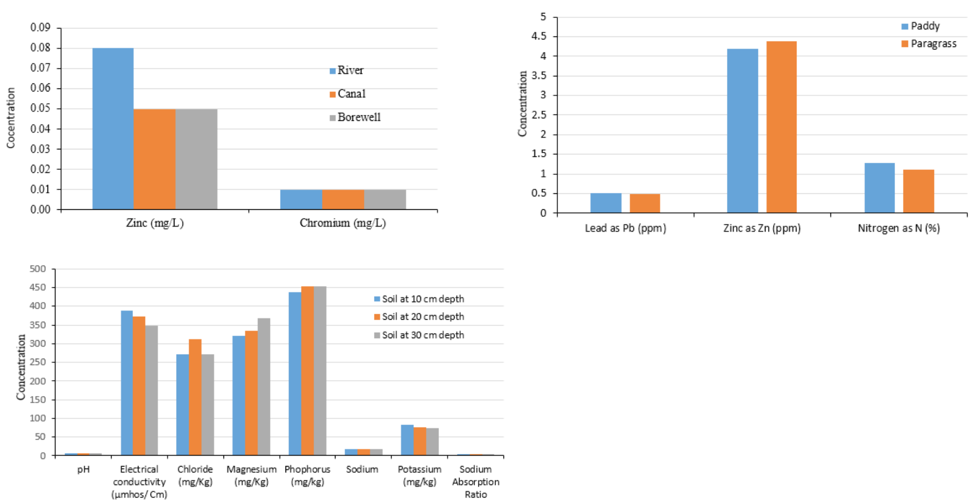

Figure 5. Chemical concentrations in water, soil and crops at Gourelli Village in the Musi catchment

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seasons Kharif (2012) and Rabi (2012-13) [51] . At four villages along the Musi river corridor, namely 1. Peerzadiguda 2). Parvathapuram 3). Prathapsingaram 4). Gourelli in Hyderabad where, wastewater irrigation is being used to grow paddy, fodder grass and vegetables (Figure 4). The fodder grass was supplied to feed the living stock mainly cows and buffalos. The soil and fodder samples were analyzed for pH, Electrical conductivity, Organic carbon, Nitrogen, Iron, Manganese, Zinc, Copper and the heavy metals Lead, Cadmium, Nickel, Cobalt, and Chromium and compared with non-polluted area. The results of at four villages that the pH of soil samples is slightly neutral to basic and cadmium (Cd) value of soil samples in rabi season was exceeding the permissible limit [51]. This is due to the no rains in rabi season, lack of dilution, cadmium concentration was high in wastewater applied to soil for growing crops. The plant's soil pH increases consequently, its food's pH value becomes too high, due to this the plant's ability to absorb certain nutrients is disrupted. Long-term exposure to cadmium through the air, water, soil, and food leads to cancer and organ system toxicity such as skeletal, urinary, reproductive, cadmium contamination causes cancer to human beings and animals. The remaining parameters, Electrical conductivity, Organic carbon, Nitrogen, Iron, Manganese, Zinc, Copper, and the heavy metals Lead, Chromium, Nickel, and Cobalt in soils of Peerzadiguda of both the seasons were within the permissible limit. We also have analyzed chemical parameter concentration of soil, water (river, canal, and borewell), and fodder, that results say that groundwater is not affected by heavy metals (Figure 5). However, soil salinity in terms of chloride is very high and magnesium also very high due to wastewater application. The long-term use of untreated wastewater may impact soil salinity that may lead to water logging.

4.4 Wastewater Effects on Crop Quality

Soil and Forage grass (Paragrass) samples were collected along 8 km stretch of the Musi River, including 2 km on either side of the river, Hyderabad India. The samples were analyzed and results of zinc (zn) (164.2-212.4 μg/g), chromium (cr) (20.2-36.7 μg/g), copper (cu) (15.7-29.6 μg/g), nickel (ni) (10.7-18.3 μg/g), cobalt (Co) (3.7-7.1 μg/g) and lead (Pb) (66.7-101.7 μg/g) are reported. The Permissible values for Zn range between 1-100 (μg/g), Cr -0.03-14 (μg/g), Ni -0.02-5 (μg/g), Co - 2-10, (μg/g), and Pb range in between 5-10 (μg/g) respectively [52]. The analysis results indicated that the Zinc, Chromium Copper, Nickel Cobalt, and Lead values exceed the permissible limits of drinking water and irrigation water values prescribed by BIS (2012) standards. This is due to the disposal of industrial effluents containing a high concentration of zinc, Chromium, Copper, Nickel Cobalt in Musi wastewater which is used for irrigating the fodder grass and other crops. Lead pollution occurs due to the dumping of used electric batteries into soil and water bodies and from automobile exhausts hence, regular monitoring of metal concentration in soil is imperative [52]. However, in the present our analysis reports at Gourelli Village show that all chemical concentrations were within acceptable limits of BIS, 2012 [53] (Figure 5).

It is reported that the total irrigated water requirement for the whole Musi catchment is about 1235 Mm^3 [54]. Due to overexploitation of groundwater, aquifers were dried and wells are less or unproductive. At the same huge waste water is available to the downstream of Hyderabad at the of 1700 MLD now and it is projected to be 1955 MLD by 2031. Hence, proper treatment and reuse of the domestic wastewater can reduce stress on the aquifer and can increase the economy of the farmers. The above studies reported both positive and negative impacts of waste water reuse for irrigation and hence before introducing it into the irrigation system, the quality of reused water should be ensured to control the impacts of long-term usage. The level of treatment may adopt based on the nature of contaminants and usage of water considering the global wastewater reuse practice mentioned above sections.

5. Conclusions

The integration of improper treatment of urban domestic rejected water in irrigation will have adverse impacts on many ecosystems such as soil salinity, waterlogging, and contamination of both groundwater and surface water. The contaminated water can damage the wildlife ecosystem and the food-chain and eventually the prevalence of diseases. In order to effectively utilize the huge quantity of wastewater to reduce the water stress in the urban catchments, a proper treatment mechanism should be established. After ensuring its quality, it can be integrated into water resource planning and management for beneficial reuse in irrigation. It is highly recommended that reuse of wastewater for irrigation or any other requirements after reaching the required quality standards prescribed by US EPA or local country guidelines to minimize the potential risks to the public health and environment.

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