ASSESSMENT OF THE QUALITY OF RECOVERY WATER USING FOR CROP IRRIGATION-A CASE STUDY

Abstract

The study was carried out to analyse heavy metal content in water soil and vegetables of Narsapura lake catchment in Kolar District, Karnataka receiving water from KC Valley Sewage Treatment Plant. Samples were collected from selected locations in the study site during 2020 dryseason and analyzed for six heavy metals as per the APHA standard methods and level of contamination was recorded. Cu and Zn not detected in any of the three sets of samples. But Ni, Fe, Pb and Cd were exhibited at very high concentrations when compared to prescribed PFA standards. The analytical results of the present study revealed that the vegetables grown using the recycled water in Kolar district is significantly containing heavy metals. The consumers who are using it are at higher risk of acquiring diseases which will definitely diminish human's health at a rapid rate. Further in treatment advanced technologies to be adopted and should ensure properly the quality of the treated water, which draining into Kolar lakes for recharging ground water and irrigation needs.

Keywords: Heavy metal, Sewage, Groundwater, Vegetables, Soil etc.

Authors

Venkatesha Raju K
Presidency University
Bangalore, Karnataka, India.

Guruprasad N.M
Reva University
Bangalore, Karnataka, India.

Sridar Babu M.N
The Energy and Resources Institute (TERI)
Bangalore, Karnataka, India.

Mukamba S.B
Reva University
Bangalore, Karnataka, India.

Santhosh M.B
Presidency University
Bangalore, Karnataka, India.

I. INTRODUCTION

The process of sewage treatment involves eliminating contaminants from municipal wastewater, which primarily consists of sewage from homes and potentially some industrial effluent. Physical, chemical, and biological techniques are used during the treatment process to remove contaminants and create treated wastewater that is safe to release back into the environment. Organic matter, nutrients (nitrogen, phosphorus, and potassium), inorganic matter (dissolved minerals), hazardous compounds, and pathogens are among the main constituents of wastewater. Recovery water is another name for the treated wastewater, which is increasingly used for irrigation.

To overcome the challenges of water scarcity in the perennially arid district of Kolar in Karnataka, the Government of Karnataka launched the Koramangala and Challaghatta Valley (KC Valley) Project. The goal of the project, which is operated by the Bangalore Water Supply and Sewerage Board (BWSSB) and the Minor Irrigation Department of the Government of Karnataka, is to rejuvenate the groundwater levels in Kolar district by transporting secondary treated water from the Sewage Treatment Plants in Bellandur and Varthur lakes in Bengaluru to 126 minor irrigation tanks in Kolar district. The project envisions that this secondary treated water will percolate into the ground from these lakes/tanks and enhance the water table.

Nutrients present in recovery water could being valuable to crops and hence we are witnessing an increasing trend in its utilization for irrigational purposes, especially around large cities. However, even though secondary treated water may contain essential nutrients for plant growth, it often contains heavy metals which may be toxic for human or animal consumption if they exceed permissible limits. Recent research papers have also explained how the reuse of wastewater in agriculture affects soil texture properties adversely. The utilization of sewage wastewater in agriculture has both positive and negative consequences and this case study attempts to quantify and understand the impact secondary treated water has on the soil and food- produce quality in the agricultural fields of Kolar, which are irrigated by recovery water from the KC Valley Project.

In many regions of our country, water scarcity, caused by factors varying from population growth, economic development and climate change poses a major challenge to the country’s food security. Despite several such challenges, India ranks second worldwide in farm output (Othman A. AlMashaqbeh et al.2012). Green leafy vegetables are a good source of folic acid and iron. Expenditure on vegetables forms 11 per cent of total food expenditure in rural India and 10.5 per cent in urban India. Presently horticulture contributes 28 percent of agricultural GDP (Gross domestic product) (Neeraj et al., 2017). Agriculture is the backbone of rural India with almost 60% of the nation’s population involved in agriculture and its allied sectors for their livelihood (Veerendrakumar M. Narasalagi et al., 2017). With the advancement in technology, large farmers, in particular, can employ far more efficient agricultural and supply chain techniques which increases their yield and hence income. This is however not true for a majority of farmers in India as the country’s average landholding size is only 1.04 hectares (Indian Economic Survey 2018-19).

Historically, after the Green Revolution during the 1960s, it wasn't until 1992, that efforts were made again for the advancement of agriculture through a combination of institutional help and planned distribution of assets by the government. It was in the post-1993 period that an engaged consideration was again given to agricultural improvement through information-based innovation (Veerendrakumar M. Narasalagi et al., 2017). However, the impact of its implementation can be questioned as the efficiency of agricultural yields has expanded just barely from 7.5 tons per hectare in 1991-92 to 8.4 tons for each hectare in 2004-05 (NHB, 2005).

On the contrary, erratic and unpredictable changing patterns of climate and rainfall coupled with the overexploitation of groundwater has created a huge gap between the demand and supply of good quality water as a resource in agriculture. Population growth is putting enormous pressure on the food requirement of the country. Innovating ways to use water more efficiently is a paramount piece in the solution to both India's water crisis and food security problem. The use of recovery water for irrigation is one such innovation which could possibly address both the food security and also the nutrient requirement of crops simultaneously provided that it is managed with care by adequately considering the local conditions of the water, farmland and type of crop.

The utilization of wastewater in agriculture is a part of India's traditional agricultural practice. However, in recent times, with the advent of modern chemical agriculture, it has not been executed appropriately with the necessary additional care required to satisfy quality levels. In like manner, the information relating to wastewater use has developed throughout human history. Due to the requirement for a controlled supply that makes up for water shortages brought on by seasonality or the erratic availability of other water sources for crop irrigation throughout the hydrological year, this type of reuse is regarded as an effective tool for managing water resources (Maria Fernanda Jaramillo et al., 2017). Recovery water is used in agriculture in a lot of nations. Due to the scarcity of good-quality water, even though it is often illegal, untreated wastewater has been used to irrigate crops in several nations throughout the world (Sana Khalid et al., 2018).

Agriculture has been unlawfully using wastewater, which might be harmful to the environment and human health. Wastewater reuse warrants consideration in the context of technological advancement and in the face of a growing water problem because the method helps reduce water consumption pressure and moderates water contamination. The analysis of the literature demonstrates that, up to the 1990s, research studies advocated using treated wastewater for irrigation while suggesting "end of pipe" traditional solutions. More recent studies (2012–2016) have shown that agricultural reuse has a considerable impact on soil textural qualities and may also change the biomass and bacteria (Maria Fernanda Jaramillo et al., 2017).

Reduced stress on freshwater resources is one of the main benefits of using wastewater in agriculture. Recovery water serves as a replacement water source in this manner. An investigation found that 70% of the world's freshwater resources that are readily available are used for irrigation in agriculture. According to Maria Fernanda Jaramillo et al. (2017), wastewater reuse boosts agricultural production in areas with a lack of water, improving food safety. Apart from other significant nutritional components for plant growth, sewage water application raises soil salinity, organic carbon, and cations of N, K, Ca, and Mg. A considerable portion of the contaminants found in home waste water can be reduced by using soil as a bio filter, but this has the drawback of making the soil's levels of sodium, calcium, and magnesium rise.

Groundwater is an essential component of India's water security because it not only serves as the main source of drinking water and agricultural irrigation but also as a source of water when there is a shortage of surface water. As a result of climate change, monsoon rainfall patterns are expected to grow more unpredictable, making groundwater an even more important "buffer" water resource. As a result, groundwater depletion has a significant influence on India's water security, food security, health, and way of life (Caleb Gortan et al.).

The world's largest consumer of groundwater is India. It uses more than a quarter of the entire amount in the world, or 230 cubic kilometers annually. 85 percent of drinking water in rural areas and 48% of water needs in cities are met by groundwater from more than 30 million access points. 88% of all groundwater use is for irrigation, which is the primary use of groundwater. Around 700 million Indians live in rural areas of the country and depend on groundwater for their daily needs. 1,017 groundwater units were judged to be "overexploited" in a 2011 study of 6,607 groundwater units, meaning the rate of groundwater withdrawal surpassed replenishment. In India, about one-third of all units were under pressure (Caleb Gortan et al)

For Kolar According to S.N. Ramaiah et al., more than 90% of bore wells that were equipped with hand pumps for water supply and tapped aquifers up to 150 m deep are completely dry. Only deep bore wells with submersible pumps, ranging in depth from 200 m to 350 m, are now meeting the water supply needs of the Malur taluk- Kolar district and several nearby villages. Groundwater overuse in the area has a major influence not only on the groundwater system but also on local food production. According to S.N. Ramaiah et al., eucalyptus groves increasingly took the place of the agricultural land where food crops once grew.

The study found that excessive groundwater exploitation had a negative impact on the local population's requirement for drinking water. Back in the 1990s, shallow bore wells with a depth of 90 to 200 meters rapidly replaced open wells used for agriculture and drinking water by the populace. At the moment, deep bore wells with depths ranging from 200 to more than 300 m are replacing these shallow bore wells. Even many of these bore wells are either dry or only sometimes release water (S.N. Ramaiah et al.,). The ever-increasing exploitation of groundwater can be greatly reduced by using well cleaned recovery water for irrigation. The infiltration of recovery water into the earth is an additional benefit.

Reusing rural wastewater has the potential to reduce the costs associated with hiring or purchasing groundwater-related equipment, such as water pumps, and the associated electricity costs for impoverished farming households. The resulting reduction in demand on freshwater supplies is a benefit of wastewater usage in agriculture. As a result, wastewater is used as an alternate source of irrigation, particularly for agriculture, the largest worldwide water user, which uses 70% of the water supply. Additionally, wastewater reuse raises agricultural output in areas with a lack of water, improving food safety (Maria Fernanda Jaramillo et al., 2017). Farmers' purchasing power and capacity to preserve money and make additional investments in cutting-edge, environmentally friendly agricultural methods rise as crop yields rise.

Since fertilizer costs can be reduced thanks to the nutrients naturally found in wastewater, a closed and environmentally friendly nutrient cycle is ensured, preventing the indirect return of macro- (particularly nitrogen and phosphorus) and microelements to water bodies. (2017) Maria Fernanda Jaramillo et al. Wastewater may be a source of full-scale macronutrients (N, P, and K) and micronutrients (Ca, Mg, B, Mg, Fe, Mn, or Zn), depending on the supplementation. Reusing wastewater has been shown to increase crop output and reduce the need for fertilizers and compost in horticulture and agriculture.

Depending on the sanitary and socioeconomic circumstances in a given community, different regions have different concentration levels and types of diseases and chemical compounds. In developing nations, the concentration of viruses, protozoan parasites, and helminths in wastewater can range from 10 to 1000 times greater. If consumed untreated or utilized for agriculture, the recovery water's presence of specific microorganisms could result in water-borne illnesses. They might be acute or persistent. Acute risk is the chance of getting sick quickly after being exposed to small amounts of an infectious pollutant, whereas chronic risk is the existence of chemical pollutants that have long-term effects on human health.

The concentration levels and types of pathogens and chemical substances present in wastewater vary by region, according to the sanitary and socio- economic conditions of a particular community. The concentration of viruses, protozoan parasites and helminths in wastewater can be 10–1000 times higher in developing countries. The presence of certain pathogens in the recovery water may cause water- borne diseases if consumed directly or if used for agriculture without sufficient treatment. They can be chronic or acute. Acute risk corresponds to the possibility of becoming ill in the short-term when exposed to low infectious doses of a pollutant, whereas chronic risk refers to the presence of pollutants of a chemical nature that affect human health after long periods of exposure. Additionally, microbial diseases can be directly or indirectly transmitted by water (Maria Fernanda Jaramillo et al., 2017). Globally, such diseases have significantly contributed to premature mortality, especially in developing countries.

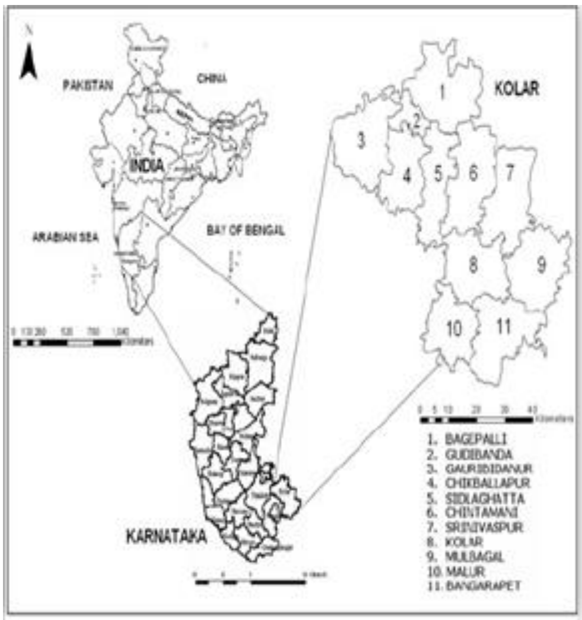
Other compounds present in irrigated wastewater that may pose risks to human health are emerging contaminants (ECs). ECs are molecules with biological activity on different organisms, and their physicochemical properties determine their persistence in the environment and facilitate their bioaccumulation. ECs include analgesics, antihypertensive drugs and antibiotics, among others. Furthermore, some ECs correspond to endocrine disrupters (EDs). Such substances, of complex nature, were not considered contaminants in the past, because of a lack of information on their accumulation in soil, water, air and vegetal and animal tissue (Maria Fernanda Jaramillo et al., 2017).

On the soil quality/productivity, crop production, and human health, the use of wastewater for crop irrigation in the agricultural sector has the potential to have both positive and negative consequences. Unwanted bacteria and chemical components that pose dangers to human health and the environment may be present in wastewater. The presence of high total suspended and dissolved particles, as well as high nutrient levels, is the main cause of the detrimental effects of wastewater irrigation on crop growth. High salt concentrations in wastewater may have an impact on the soil's quality and productivity by building up in the root zone. Long-term usage of wastewater that is salty and sodium-rich can harm the structure of the soil and reduce its productivity. The salinization of soil brought on by wastewater irrigation has been widely documented in recent years. Heavy metals, which are known to have a negative impact on crop productivity, are the main cause of wastewater's significant impact on crop productivity. Additionally, viruses, bacteria, nematodes, and protozoa that can cause various diseases may be present in wastewater. Application of wastewater may also modify the soil's physico-chemical characteristics, which in turn alters the soil's fertility and quality (Sana Khalid et al.).

The objective of the present study is to determine the quality of soil, secondary treated waste water used for irrigation and food produce from farmland which uses such waste- water directly for irrigation. Then to compare it with national and international consumption standards. Finally reveal scope for expanding the research.

II. EXPERIMENTAL APPROACH

1. **Study Site:** Karnataka is a state in Southern India which is diverse in its geography ranging from the coastal plains along the Western coast to high mountain ranges in the form of the Western Ghats (which receives tremendous rainfall during the South-Western Monsoon) to the arid lands in its interior. Due to its geography, it exhibits a spectacular variety in its biodiversity and climate pattern which heavily affects the type of agriculture practiced in the respective regions. Consequently, it is also renowned for its exceptional tourist attractions in each district.



(Source: https://www.researchgate.net/figure/Study-Area-Kolar-District-Karnataka-State-India)

Kolar is one of the districts in Karnataka which is most drought-hit and depleted ground waters.

People main livelihood is agriculture (horticultural crops) in Kolar along with milk production and sericulture. The farmers in the Kolar district's economy rely heavily on ground water. In older times, irrigation facilities provided by numerous widely dispersed tanks were the main source of support for agriculture. Farmers now primarily rely on bore wells for their agricultural needs due to drought conditions. The district has over 1, 22,910 bore wells, which illustrates how heavily farmers rely on ground water. The other taluks have all been overused. The district experiences an average annual overdraft of 56,363 hams, which causes the water table to continuously decline.

Even though Kolar district has the most irrigation tanks in Karnataka (4488 tanks), its dependence for irrigation again depends on rainfall amounts. Therefore, ground water has a specific significance for the overall development of this territory that lacks access to water and is prone to drought. Less than 1% of the total annual rainfall occurs in the winter months of January and February, 7% in the hot pre-monsoon months of March and May, and 12% in the post-monsoon months. (Karnataka's Bangalore Climate Change Initiative). The traditional crops planted in Kolar include finger millet, horse gram, field bean, red gram, mango, tomato, potato, mulberry, and others. According to N. Harish et al., finger millet takes up around 26% (52,491 ha) of the total cultivated area.

2. **Sample Collection:** A walk through was steered at the outlet point before the sample collection to identify the location for sampling. Samples were collected for three types of test objects like soil samples, water samples and food produce collected from the test site (farmland) which is irrigated by water from the KC Valley water channel outlet. Food

produce includes Tomato, Ladies Finger, Cucumber, Gourd, Flat pea beans, Pigeon pea, Long cow pea beans. A thoroughly cleaned 2L plastic container was used for water collection and transported to laboratory immediately in freezing condition using sampling kit. The vegetables grown in the test site which was irrigated by secondary treated water while wearing hand gloves and stored them in cleaned and sterilized bags and transported to the laboratory in a secure manner. In the third visit the soil samples from the farmland were collected as per the standard soil collection protocol.

3. **Analysis of quality parameters:** APHA 2017, analytical methods were applied to analyse all the physicochemical and heavy metal parameters in the collected samples of the study area.

III. RESULTS AND DISCUSSION

1. **Water Samples:** In water samples both physico-chemical and metals values are depicted in table

- The obtained value of pH was 9.26 units clearly indicates the cause of salinity if KC valley water used for irrigation purpose incessantly without any measures to control it. In case metals Nickel (0.054mg/l), and Lead (0.114mg/l) recorded higher concentration compared to permissible limits (Table 2), may lead to bioaccumulation and biomanification of metals.

Table 1: Analytical Results of Water

Slno	**Parameters**	**Obtained Results**	**Permissible limitsas per the PFAAct,1954**	**Methods of Analysis**
1	Phat25̊C	9.26	8.5	APHA23rd EDITION,2017,4500B
2	Conductivity@25̊C	732(µS/cm)	2250	APHA23rd EDITION, 2017, 2510B
3	Turbidity(NTU)	0.1(NTU)	5	APHA23rdEDITION, 2017,2130B
4	Cupper as Cu	ND	0.05	APHA23rdEDITION,2017 B 3111B
5	Nickelas Ni	0.054(mg/l)	0.002	APHA 23rd EDITION, 3111B:2017
6	ZincasZn	ND	5	APHA 23rd EDITION, 3111B:2017
7	Ironas Fe	0.139(mg/l)	0.3	APHA 23rd EDITION,3111B:2017

8	LeadasPb	0.114	0.005	APHA 23rd EDITION, 3111B:2017
9	Cadmiumascd	0.014	0.01	APHA23rd EDITION,3500:2017
10	Total dissolvedsolids	422(mg/l)	500	APHA23rd EDITION,2540C 2017,
11	BOD	32(mg/l)	-	APHA23rdEDITION,5210 B 2017
12	COD	150(mg/l)	-	APHA 23rdEDITION, 5220B 2017
13	Dissolvedoxygen	4.8(Mg/l)	-	APHA23rdEDITION, 2017 4500-OC:
14	*E.Coli*	14 Cfu/ 100ml	-	IS15185:2002(RA2014)

- **Soil Samples:** In soil samples Ni,i, Fe, Pb and Cd recorded maxima with 26.9, 12991, 54 and 20.6 mg/kg co respectively. While Cu and zinc are not detectable. Higher concentration of metals significantly affects the plant growth and its yield by its metal toxicity. E. coli count was noticeable in soil sample may deteriorate the receiving water bodies as well as ground water.

Table 2: Analytical Results of Water

Slno	Parameters	Obtained result (mg/kg)	Permissible limits (mg/kg) as per the PFAAct,1954	Analytical Method
1	Copper as Cu	ND	2.3	APHA23rdEDITION,3111B:2017
2	Nickelas Ni	26.9	1.5	APHA23rdEDITION,3111B:2017
3	ZincasZn	ND	60	APHA23rdEDITION,3111B:2017
4	Ironas Fe	12991	425	APHA23rdEDITION,3111B:2017
5	LeadasPb	54.0	0.3	APHA23rdEDITION,3111B:2017
6	Cadmium as Cd	20.6	0.1	APHA23rdEDITION, 3111B:2017
7	E.Coli	08 Cfu/ml	-0	IS15185:2002(RA2014)

- **Vegetables samples:** Cu was not detected in any vegetables samples which are subjected to analysis. Cu and Zn are essential metals for plant growth, although these are also putatively toxic, when they accumulate in cells at excess. But all the other analyzed metals such as Ni, Fe, Pb and Cd showed more concentration when compared to PFA Act 1954 standard limits. Narsapura, Kolar district environmental samples have various heavy metals like Cu, Ni, Zn, Fe, Pb and Cd. It is evident that the above-mentioned vegetables significantly concentrated the toxic heavy metal and beyond the prescribed limits as per PFA Act 1954 (Table 3).

IV. CONCLUSION

The Variation in the heavy metal concentration may be due to the contamination of soil and water it happens when the water comes from the sewage, industries and contaminated ground water. These contaminants are highly toxic and are persistent, accumulates in water, sediment and in the tissues of living organisms through the mechanisms of bio concentration and bio magnification. The crops grown initializing these soil and water can make a negative impact to Human lives by Diminishing distorting one's health. Hence advancement's in maintaining standards by providing a proper economic solutions and technologies and should be implemented in order to have a fertile soil and better water quality. A detailed study of such waters is essential in the interest and wellbeing of mankind.

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Table 3: Analytical Results of Vegetables.

Sl no	Parameters (mg/kg)	Tomato	Ladies finger	Cucumber	Gourd	Long cow pea beans	Pigeon pea	Flat pea beans	Analytical Method
1	Copper as Cu	ND	ND	ND	ND	ND	ND	ND	APHA 23rd EDITION, 3111 B: 2017
	Permissible Limit	25.42	22.59	15.53	32.13	14.82	14.17	14.82	
2	Nickel as Ni	92.6	163.7	101	107.7	97.5	104.1	97.9	APHA 23rd EDITION, 3111 B: 2017
	Permissible Limit	0	66.4	0	1.62	0	0	0	
3	Zinc as Zn	ND	ND	ND	ND	ND	ND	ND	APHA 23rd EDITION, 3111 B: 2017
	Permissible Limit	10.13	33.98	9.47	52.61	0	5.19	0	
4	Iron as Fe	398.8	465.5	510.5	353.4	357.4	371.1	336.5	APHA 23rd EDITION,3111 B: 2017
	Permissible Limit	107.95	198.55	182.1	279.51	167.71	191.34	167.7	
5	Lead as Pb	73.6	694.5	40	94.1	81.1	19.8	77.7	APHA 23rd EDITION,3111 B: 2017
	Permissible Limit	0	44.4	37.03	74.07	0	27.12	0	
6	Cadmium as Cd	27.2	37.5	40.5	48.8	44.8	51.7	53.7	APHA 23rd EDITION, 3500:2017
	Permissible Limit	0	0	0	0	0	0	0	

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