ಮಾನ್ಯ ವಿಧಾನ ಪರಿಷತ್ತಿನ ಸದಸ್ಯರಾದ ಶ್ರೀ ಶಿವಕುಮಾರ್ ಕೆ. ರವರು ನಿಯಮ-**72** ಅಡಿಯಲ್ಲಿ ನೀಡಿರುವ ಗಮನ ಸೆಳೆಯುವ ಸೂಚನೆ ಸಂಖ್ಯೆ:**18**ಕ್ಕೆ ಉತ್ತರ

ಸೂಚನೆ: ಬೆಂಗಳೂರು ಕೊಳಚೆ ನೀರನ್ನು BWSSB ಮೂಲಕ ಸಂಸ್ಕರಿಸಿ ಕೋಲಾರ ಮತ್ತು ಚಿಕ್ಕಬಳ್ಳಾಪುರ ಜಿಲ್ಲೆಗಳ ಕೆರೆಗಳನ್ನು ತುಂಬಿಸುವ ಕೆ.ಸಿ ವ್ಯಾಲಿ ಯೋಜನೆಯು ಈ ಭಾಗದ ರೈತರಿಗೆ ಅತ್ಯಂತ ಆಶಾದಾಯಕವಾಗಿದೆ. ಸುಮಾರು 1,400 ಕೋಟಿ ರೂಪಾಯಿ ವೆಚ್ಚದ ಈ ಯೋಜನೆಯಡಿ ಈಗಾಗಲೇ 126 ಕೆರೆಗಳಿಗೆ ನೀರು ಹರಿಸಲಾಗಿತ್ತಿದ್ದು, ಎರಡನೇ ಹಂತದಲ್ಲಿ ಮತ್ತಷ್ಟು ಹಳ್ಳಿಗಳಿಗೆ ನೀರು ನೀಡುವ ಕಾರ್ಯಕ್ರಮ ಜಾರಿಯಲ್ಲಿದೆ. ಆದರೆ, ಈ ಯೋಜನೆಗೆ ಸಂಬಂಧಿಸಿದಂತೆ ಸಾರ್ವಜನಿಕರಲ್ಲಿ ಮತ್ತು ತಜ್ಞರಲ್ಲಿ ಎದುರಾಗಿರುವ ಗಂಭೀರ ಆತಂಕಗಳ ಕುರಿತು ನಿಯಮ 72ರ ಅಡಿಯಲ್ಲಿ ಮಾನ್ಯ ಸಣ್ಣ ನೀರಾವರಿ ಮತ್ತು ಅಂತರ್ಜಲ ಅಭಿವೃದ್ಧಿ ಸಚಿವರ ಗಮನಸೆಳೆಯ ಬಯಸುತ್ತೇನೆ.

** *** **

ಕೆ.ಸಿ. ವ್ಯಾಲಿ ಯೋಜನೆಯಡಿ ಬೆಂಗಳೂರು ನಗರ ನೀರು ಸರಬರಾಜು ಮತ್ತು ಒಳಚರಂಡಿ ಮಂಡಳಿಯ ಕೆ.ಸಿ. ವ್ಯಾಲಿ ಸಂಸ್ಕರಣಾ ಘಟಕದಿಂದ ಪಡೆಯುವ ದ್ವಿತೀಯ ಹಂತದಲ್ಲಿ ಸಂಸ್ಕರಿಸಿದ ತ್ಯಾಜ್ಯ ನೀರನ್ನು ಏತ ನೀರಾವರಿ ಮುಖಾಂತರ ಕೋಲಾರ ಮತ್ತು ಚಿಕ್ಕಬಳ್ಳಾಪುರ ಜಿಲ್ಲೆಗಳ ಕೆರೆಗಳ ಅಂತರ್ಜಲ ಅಭಿವೃದ್ಧಿಗಾಗಿ ಹರಿಸಲು ಯೋಜಿಸಲಾಗಿದ್ದು, ಈ ನೀರಿನ ನೇರ ಬಳಕೆಯನ್ನು ನಿರ್ಬಂಧಿಸಲಾಗಿರುತ್ತದೆ.

ಸದರಿ ಏತ ನೀರಾವರಿ ಯೋಜನೆಯಿಂದ ಕೆರೆಗಳಿಗೆ ತುಂಬಿಸುತ್ತಿರುವ ನೀರಿನ ಗುಣಮಟ್ಟವನ್ನು ಪೂರ್ವಭಾವಿಯಾಗಿ ಪರಿಶೀಲಿಸಲಾಗುತ್ತಿದ್ದು, ನೀರಿನ ಗುಣಮಟ್ಟವು ಕೇಂದ್ರ ಮಾಲಿನ್ಯ ನಿಯಂತ್ರಣ ಮಂಡಳಿ ಹಾಗೂ ರಾಷ್ಟ್ರೀಯ ಹಸಿರು ನ್ಯಾಯಮಂಡಳಿಯ ಮಾನದಂಡಗಳ ಅನುಗುಣವಾಗಿರುತ್ತದೆ. ಕೆ.ಸಿ.ವ್ಯಾಲಿಯ ತ್ಯಾಜ್ಯ ಸಂಸ್ಕರಣಾ ಘಟಕದ ಬಳಿ ಹಾಗೂ ಯೋಜನೆಯ ಚೌಡೇನಹಳ್ಳಿ ಕೆರೆಯ ನೀರಿನ ಗುಣಮಟ್ಟದ ವಿವರಗಳು ಈ ಕೆಳಗಿನಂತಿದೆ.

Parameters	NGT Standard	CPCB (Designated best - use water quality	STW near Outlet of STP	STW in Chowdenahalli tank
Ph	6.5 - 9.0	6.5 - 8.5	7.6	7.4
BOD	10	$\leq$2, <3	9 $\pm$ 1	3.7 $\pm$ 0.8
DO (mg/l)	NS	$\geq$6, $\geq$5, $\geq$ 4	4.5	8.5 $\pm$ 2.1

ಕೆ.ಸಿ.ವ್ಯಾಲಿ ಯೋಜನೆಯಿಂದ ನೀರನ್ನು ನೇರವಾಗಿ ಕೃಷಿ ಚಟುವಟಿಕೆಗಳಿಗೆ ಒದಗಿಸದೇ, ಕೆರೆಗಳಿಗೆ ನೀರು ತುಂಬಿಸುವುದರಿಂದ ಅಂತರ್ಜಲ ಅಭಿವೃದ್ಧಿಯಾಗಿ ರೈತರು ತಮ್ಮ ತೆರೆದ ಬಾವಿ, ಕೊಳವೆ ಬಾವಿಗಳಿಂದ ಕೃಷಿ ಚಟುವಟಿಕೆಗಳಿಗೆ ನೀರನ್ನು ಬಳಸುತ್ತಿದ್ದಾರೆ. ಯೋಜನೆಯಿಂದ ಒದಗಿಸಲಾಗುತ್ತಿರುವ ನೀರನ್ನು ನೇರವಾಗಿ ಕೃಷಿ ಚಟುವಟಿಕೆಗಳಿಗೆ ಉಪಯೋಗಿಸುವ ಕುರಿತು ಹಾಗೂ ನೀರಿನ ಬಳಕೆಯಿಂದ ಕೃಷಿ ಉತ್ಪನ್ನಗಳ ಮೇಲೆ ಉಂಟಾಗಬಹುದಾದ ಪರಿಣಾಮಗಳ ಕುರಿತು ಅಧ್ಯಯನ ಕೈಗೊಳ್ಳಲು "ಸೊಸೈಟಿ ಫಾರ್ ಇನೋವೇಷನ್ & ಡೆವೆಲಪ್‌ಮೆಂಟ್, ಭಾರತೀಯ ವಿಜ್ಞಾನ ಸಂಸ್ಥೆ" ಇವರಿಗೆ ವಹಿಸಲಾಗಿದ್ದು, ಸದರಿ ಸಂಸ್ಥೆರವರು ಸಂಶೋಧನೆಯನ್ನು ಕೈಗೊಂಡು ವರದಿಯನ್ನು ನೀಡಿದ್ದು, ವರದಿಯ ಪ್ರತಿಯನ್ನು **ಅನುಬಂಧ-1** ರಲ್ಲಿ ಅಡಕಗೊಳಿದೆ. ವರದಿಯ ಸಾರಾಂಶವು ಈ ಕೆಳಕಂಡಂತಿದೆ:

> "...The outcomes of study indicated no negative impact on soil properties when using indirectly recharged Groundwater (GW) where as a positive significant impact was reduced soil salinity in impacted areas. No microbiological contamination in terms of pathogens was found on tested soil and crop samples. Hence, indirectly recharged Groundwater (GW) using Secondary treated water (STW) could be safely used as an alternative source for irrigation overcoming the concerns of heavy metal and micro contaminants and pathogens associated with the direct use of partially treated or untreated mixed municipal Waste Water (WW) for irrigation...".

ಭಾರತೀಯ ವಿಜ್ಞಾನ ಸಂಸ್ಥೆಯು ಕೆ.ಸಿ.ವ್ಯಾಲಿ ಯೋಜನೆಯಿಂದ ತುಂಬಿಸಿರುವ ಕೆರೆಗಳ ಸುತ್ತಮುತ್ತಲಿನ ಪ್ರದೇಶಗಳಲ್ಲಿ ಸಂಶೋಧನೆಯನ್ನು ಕೈಗೊಂಡು ವರದಿಯನ್ನು ನೀಡಿದ್ದು, ವರದಿಯ ಪ್ರತಿಯನ್ನು **ಅನುಬಂಧ-2** ರಲ್ಲಿ ಅಡಕಗೊಳಿಸಿದೆ. ವರದಿಯ ಸಾರಾಂಶವು ಈ ಕೆಳಕಂಡಂತಿದೆ:

"...The secondary treated water which is being pumped to Kolar from Secondary treated plant (STP) at K & C Valley and Bellandur does not contain any harmful heavy metals above the prescribed limit even as per drinking water standards IS:10500-2012..."

ಭಾರತೀಯ ವಿಜ್ಞಾನ ಸಂಸ್ಥೆರವರು ಕೆ.ಸಿ.ವ್ಯಾಲಿ ಯೋಜನೆಯಿಂದ ತುಂಬಿಸಿರುವ ಕೆರೆಗಳ ನೀರಿನ ಗುಣಮಟ್ಟದ ಅಧ್ಯಯನ ಹಾಗೂ ಕೆರೆಗಳ ಸುತ್ತಮುತ್ತಲಿನ ಪ್ರದೇಶಗಳಲ್ಲಿ ಸಂಶೋಧನೆಯನ್ನು ಕೈಗೊಂಡು ವರದಿಯನ್ನು ನೀಡಿದ್ದು, ವರದಿಯ ಪ್ರತಿಯನ್ನು **ಅನಬಂಧ-3** ರಲ್ಲಿ ಅಡಕಗೊಳಿಸಿದೆ. ವರದಿಯ ಸಾರಾಂಶವು ಈ ಕೆಳಕಂಡಂತಿದೆ:

- Impacted tanks surface water quality meets the Hon'ble NGT standards for all parameters except E-coil and surface water quality of impacted tanks is better than the water quality of rainfed non-impacted tanks.
- Heavy metals are not detected in the surface water of both impacted and non- impacted tanks. The heavy metal levels are meeting drinking water standards as per IS 10500:2012.
- The ground water quality post implementation of K&C valley project has significantly improved for all the parameters.
- Based on data collected by the Directorate of Health and Family Welfare Services, Government of Karnataka, the analysis indicates that the reuse of secondary treated wastewater for indirect groundwater recharge through the Soil Aquifer Treatment technique does not adversely affect public health. On the contrary, improvements in hygiene and WASH scores were observed as witnessed by the decline in waterborne diseases.
- This positive outcome can be attributed to better water availability, improved sanitation and hygiene practices, and enhanced nutritional intake. In the context of growing water scarcity, particularly in semi-arid regions.

ಭಾರತೀಯ ವಿಜ್ಞಾನ ಸಂಸ್ಥೆಯ ನೇತೃತ್ವದಲ್ಲಿ ರಚಿಸಲಾದ ತಜ್ಞರ ಸಮಿತಿಯು ಕೆ.ಸಿ ವ್ಯಾಲಿ ಯೋಜನೆಯನ್ನು ಕಳೆದ 5 ವರ್ಷಗಳಿಂದ ಅಧ್ಯಯನ ನಡೆಸಿದ್ದು, ಕೆ.ಸಿ.ವ್ಯಾಲಿ ಯೋಜನೆಯ ಸಂಸ್ಕರಿಸಿದ ತ್ಯಾಜ್ಯ ನೀರು ಅಂತರ್ಜಲ ವೃದ್ಧಿಗೆ ಯೋಗ್ಯವಾಗಿದ್ದು ಈ ಕೆಳಕಂಡ ಸಕಾರಾತ್ಮಕ ಪರಿಣಾಮಗಳ ಕುರಿತು ಅಧ್ಯಯನ ವರದಿಯಲ್ಲಿ ದೃಢಪಟ್ಟಿರುತ್ತದೆ:

- ಅಂತರ್ಜಲ ಮಟ್ಟವು ಅಭಿವೃದ್ಧಿಯಾಗಿದ್ದು, ಅಂತರ್ಜಲ ಗುಣಮಟ್ಟವು ಸಹ ಸುಧಾರಣೆಯಾಗಿರುತ್ತದೆ.
- ನೀರಿನ ಹೆಚ್ಚಿನ ಲಭ್ಯತೆಯಿಂದಾಗಿ ಕೃಷಿ ಉತ್ಪನ್ನಗಳಲ್ಲಿ ಗಣನೀಯ ಹೆಚ್ಚುವರಿ.
- ಹಾಲು ಮತ್ತು ಮೀನಿನ ಉತ್ಪಾದನೆಯಲ್ಲಿ ಗಣನೀಯ ಹೆಚ್ಚುವರಿ.
- ರೈತರ ಆದಾಯದಲ್ಲಿ ಗಣನೀಯ ಹೆಚ್ಚಳಿಕೆ.
- ಗ್ರಾಮೀಣ ಆರ್ಥಿಕತೆಯಲ್ಲಿ ಪುನಶ್ಚೇತರಿಕೆ.
- ವಲಸೆ ಹಕ್ಕಿಗಳ ಪುನರಾಗಮನ ಮತ್ತು ಹೆಚ್ಚಿದ ಪ್ರವಾಸೋದ್ಯಮ.

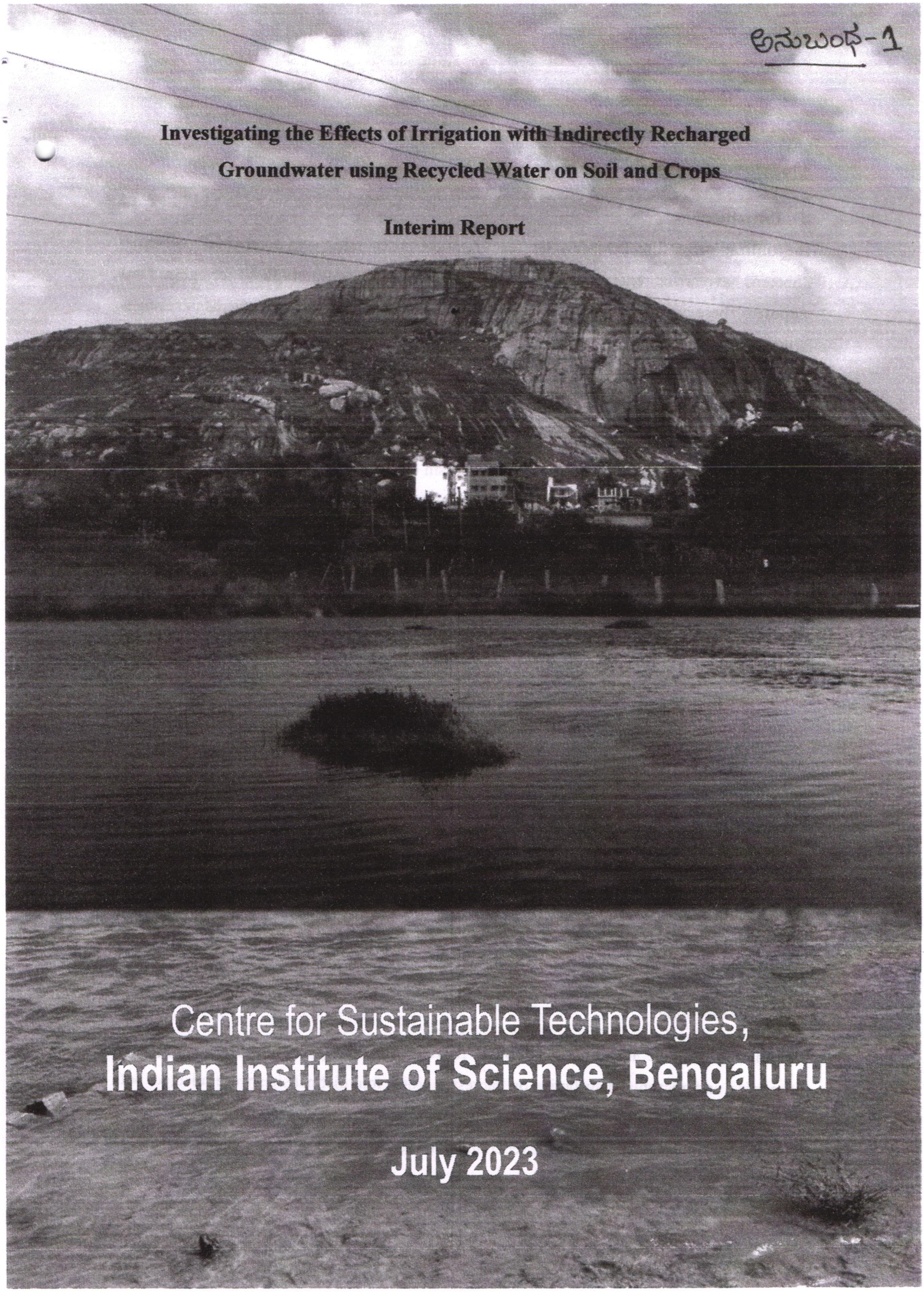
ಇದಲ್ಲದೆ, ಸದರಿ ಸಂಸ್ಕರಿಸಿದ ನೀರನ್ನು ನೇರವಾಗಿ ಕುಡಿಯುವುದಕ್ಕಾಗಲೀ ಅಥವಾ ಕೃಷಿ ಚಟುವಟಿಕೆಗಳಿಗಾಗಲೀ ನೀಡಲಾಗುತ್ತಿಲ್ಲ ಎಂಬ ಮಾಹಿತಿಯನ್ನು ಸೂಚನಾ ಫಲಕದಲ್ಲಿ ಪ್ರತಿ ಕೆರೆಯ ಮುಂದೆ ಸ್ಪಷ್ಟವಾಗಿ ಅಳವಡಿಸಲಾಗಿರುತ್ತದೆ.

ಸಂಖ್ಯೆ: MID/01/LCQ/2026

(ಎನ್. ಎಸ್ ಬೋಸರಾಜು)

ಸಣ್ಣ ನೀರಾವರಿ, ವಿಜ್ಞಾನ ಮತ್ತು ತಂತ್ರಜ್ಞಾನ ಸಚಿವರು

ಅನುಬಂಧ-1



Investigating the Effects of Irrigation with Indirectly Recharged Groundwater using Recycled Water on Soil and Crops

Interim Report

Centre for Sustainable Technologies,

Indian Institute of Science, Bengaluru

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ANNEXURE-3

1. Introduction

The utilization of direct wastewater for irrigation poses many environmental problems. Concerns have arisen regarding the direct use of untreated wastewater (WW) for agricultural purposes. These concerns include the accumulation of organic matter and nutrients in sewage-farmed soils, referred to as "sewage sickness" (Antil, 2012; Kaur et al., 2012; Subrahmanyan, 1932); pathogen contamination of soil, leafy vegetables, and root crops (Shafiani and Malik, 2013); and potential health risks for farmers directly exposed to WW (Mehmood et al., 2019). Furthermore, the use of untreated WW may result in aesthetic issues, such as unpleasant odors, negatively impacting local communities and tourism (Jeong et al., 2016; Keraita et al., 2008). This problem becomes more complex when domestic sewage mixed with industrial WW and urban runoff is used for agriculture. Particularly WW from industries like lead-acid battery recycling and electro-plating introduces various contaminants, including heavy metals, industrial detergents, and organic compounds (Yang et al., 2021; Mehmood et al., 2019; Rezapour et al., 2019; Libutti et al., 2018; Sou et al., 2012; Khan et al., 2008). These contaminants not only adversely affect soil quality and crop growth but also pose a risk of groundwater (GW) contamination in case of human consumption (Kristanti et al., 2021). Heavy metals, for example, can potentially translocate into plant roots, posing a threat to human health when consumed (Khan et al., 2015).

By synthesizing existing literature and addressing the drawbacks associated with the direct use of WW, this study presents an alternative, safe and sustainable soil aquifer treatment (SAT) based system for indirect GW recharge using secondary treated wastewater (STW) and its use for irrigation in semi-arid region. Thus, this study aims to quantify the impacts of using indirectly recharged groundwater for irrigation on soil properties and few of the crops.

2. Methodology

2.1 Site Description

In order to examine the impacts of STW recycling on GW recharge, GW quality, soil properties, and microbial distribution on harvested crops, four distinct sites were selected, both in impacted and non-impacted areas. The impacted sites were within the range of 10 km from the discharge point (DC) which is the receiving point for STW pumped from Bengaluru. STW is distributed to all 137 surface tanks from the DC point. The nonimpacted areas are comparatively far away (40 to 60 km) from the DC point and have rain-fed runoff as the only source of water recharging GW. The radial distance of the eight sites is almost the same from their nearby tanks in impacted and non-impacted areas to maintain uniformity (Table 1).

Table 1. Sample collection details

Sample ID	Sample name	Location		Radial Distance from DC point (km)	Radial Distance from nearest lake(km)	Water Levels (mbgl)
Impacted						
1.	A	13°07'26.7"N	77°57'46.7"E	0.2	0.2	19.4
2.	B	13°08'16.4"N	77°59'55.8"E	4.3	0.1	19.1
3.	C	13°07'45.3"N	78°01'59.3"E	7.7	0.5	25.6
4.	D	13°06'54.3"N	78°03'15.1"E	10.1	0.05	25.4
Non-impacted						
5.	E	13°10'20.8"N	78°21'32.4"E	43.4	0.4	58.1
6.	F	13°12'18.6"N	78°26'00.6"E	51.9	0.2	86.8
7.	G	13°12'55.2"N	78°27'00.1"E	53.9	0.1	87.4
8.	H	13°12'18.8"N	78°30'54.0"E	60.6	0.05	53.8

2.2 Characterization of soil

The surface composite soil samples (0-30 cm) were collected in triplicate from the identified impacted and non-impacted sites. Samples were collected, air-dried, sieved through a 2 mm sieve, and stored in plastic bags. The soil samples were analysed for various physicochemical properties such as soil texture, pH, EC, available nitrogen (N), available potassium (K), available phosphorus (P), SAR, and other micronutrients as per the standard procedure and methods described by Abegunrin et al., 2016; Pansu and Gautheyrou, 2006. The microbiological analysis of the soil samples was carried out by molecular biology procedures, including DNA extraction, PCR amplification, cluster generation, and 16S rRNA sequencing. The primers employed in the study, namely 16S rRNA F (GCCTACGGGNGGCWGCAG) and 16S rRNA R (ACTACHVGGGTATCTAATCC), were synthesized at Eurofins Genomics. After preparation, the amplicon library was purified using AMPure XP beads and quantified using a Qubit fluorometer. For the subsequent data analysis, the QIIME software platform was employed, and Eurofins Scientific Co. Ltd. (Bengaluru, India) facilitated the data analysis process (Mohan et al., 2021; Levantesi et al., 2010).

Additionally, the soil samples were also tested for the presence of other specific microbes such as *Escherichia coli (E.coli)*, and total coliform as indicator organisms and *Shigella,* and *Klebsiella* as representative pathogenic bacteria. The number of microorganisms studied was determined by the spread plate technique where 25 g of sample was added to 225 mL buffered peptone water, homogenized in a stomacher and then serial dilutions in buffered peptone water were spread onto agar plates which were incubated at 37°C for 24 hrs (Libutti et al., 2018). The selective and differential media used and the appearance of tested bacterial colonies are listed in Table 2.

Table 2. Specific media for pathogen identification (USEPA, 2002)

Specific differential media	Composition	Pathogen	Appearance
Eosin methylene blue agar	Peptone, Dipotassium hydrogen phosphate, Lactose, Saccharose (Sucrose), Eosin – Y, Methylene blue, Agar	*E.coli,* and total coliform	The green metallic sheen and Purple in colour
MacConkey agar	HMC peptone, gelatin peptone, lactose monohydrate, bile salt, sodium chloride, crystal Violet, natural red, Agar	*Klebsiella, Shigella*	Mucoid dark pink and Light pink and translucent

2.3 Microbiological analysis of harvested crops

To assess the impact of irrigation with indirectly recharged GW using recycled water, three harvested crops like beetroot (root crop), tomato (seasonal crop), and one leafy vegetable (spinach) were collected which were irrigated with drip irrigation in both impacted and non-impacted GW. A minimum of five plants of each crop were chosen randomly, and utmost care was taken to maintain aseptic conditions by using disposable gloves (Farhadkhani et al., 2018). All plant samples were collected in either sterile glass containers or plastic bags and promptly transported to the laboratory for subsequent microbiological analyses. To prepare the fresh plant samples for testing, the edible parts of each crop were gently washed with sterile tap water, and surface swabs were obtained for culturing in sterile tap water, following the methods outlined by (Obeng et al., 2018; Ugwu et al., 2014). The monitoring of indicator bacteria, specifically total coliforms and *E. coli*, along with a few common microbes such as *Shigella* and *Klebsiella* were analysed using the spread plate technique with specific selective differential media (details listed in Table 2).

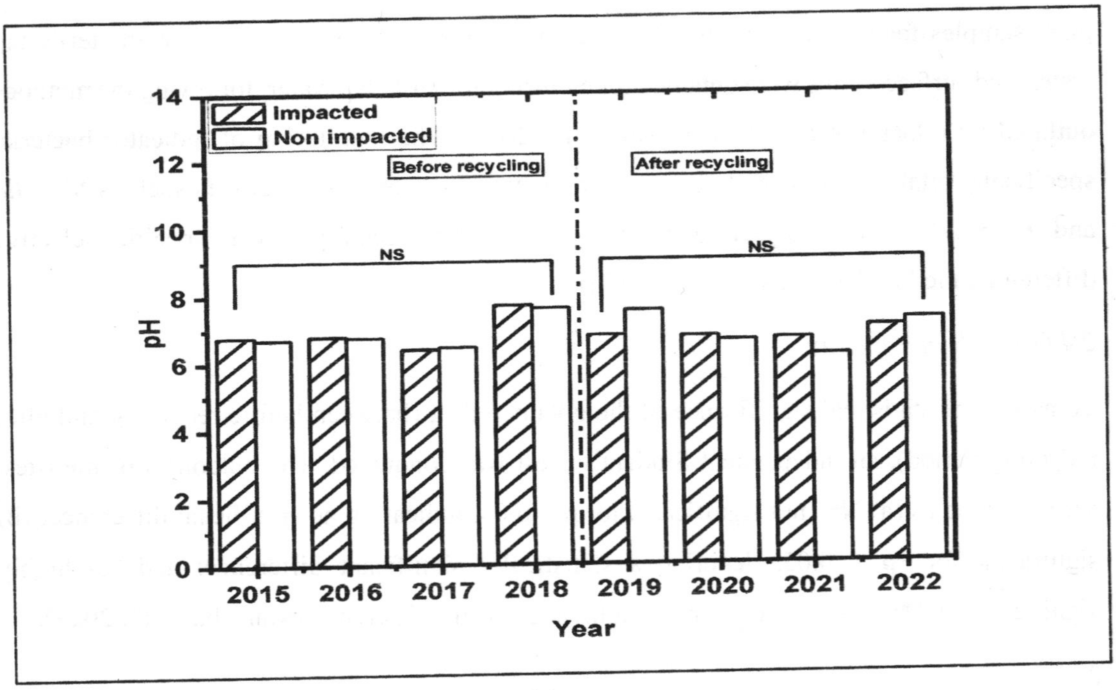
2.4 Groundwater quality

To assess the statistical significance of the obtained data (between before recycling and after recycling period), an independent Student's t-test was conducted. The outcomes of the t-test are presented as (a) NS (not significant) for $p > 0.05$, indicating no significant difference; (b) significant for $^*p < 0.05$, denoting a statistically significant difference; and (c) highly significant for $^{**}p < 0.01$, indicating a highly significant difference (Manisha et al., 2023).

3. Results

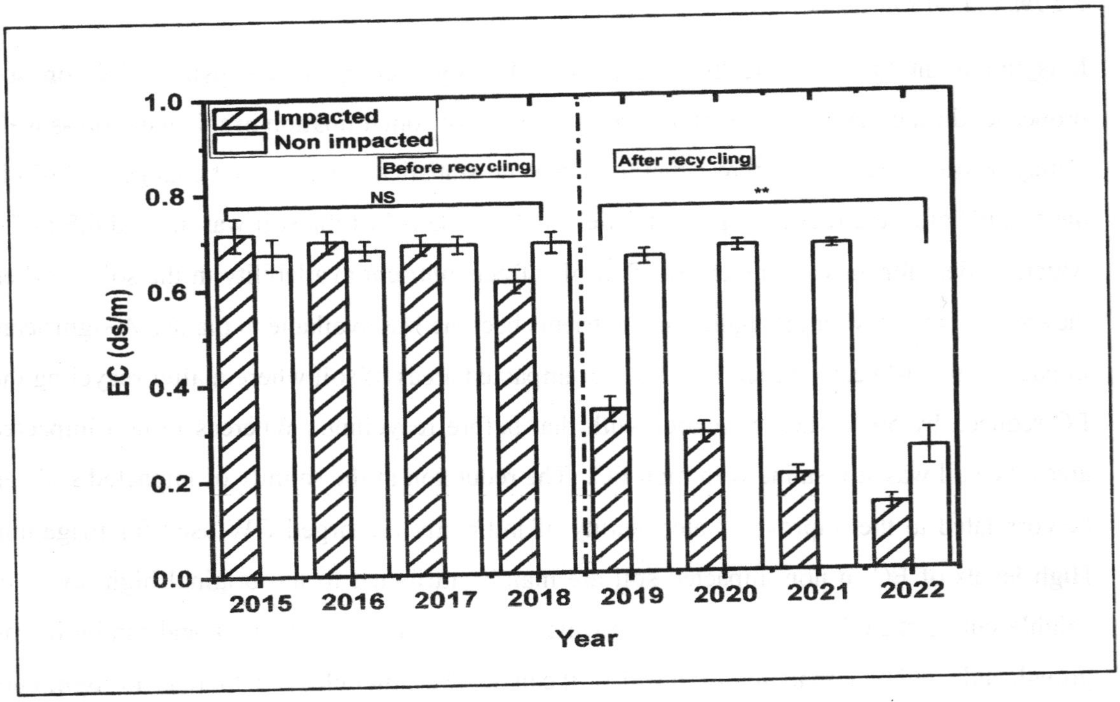
3.1 Impact on soil properties

It is important to determine the impact of indirectly recharged GW using STW on soil properties during irrigation to evaluate safety and risk of contamination in soil and crop as well. It may be observed from Figure 1 that there was no statistically significant change (> 0.05) in the soil pH after the recycling project (after 2018). The pH of the soil was around 6.5 to 7.5 which is ideal for most of the crops. Soil pH affects nutrient availability in the soil as when the soil pH is too low or too high, some nutrients become less available to plants. A significant impact ($^{**}p<0.01$) can be seen in the EC of impacted areas of soil wherein after recycling the EC reduced by 50% when compared with that before recycling. Whereas in non-impacted areas the soil was still saline with high EC. The reduction in the salinity of impacted soil can be correlated to the improved water quality of indirectly recharged GW used for irrigation. High levels of EC in non-impacted soil are mainly attributed to the original high levels of soluble salts in the GW used for irrigation which can lead to soil salinization and can limit crop growth and yield by impacting soil fertility. It can thus be concluded that there is no significant change in the soil properties such as available nitrogen (N), available potassium (K) and available phosphorous (P) where the indirectly recharged GW was used for irrigation.



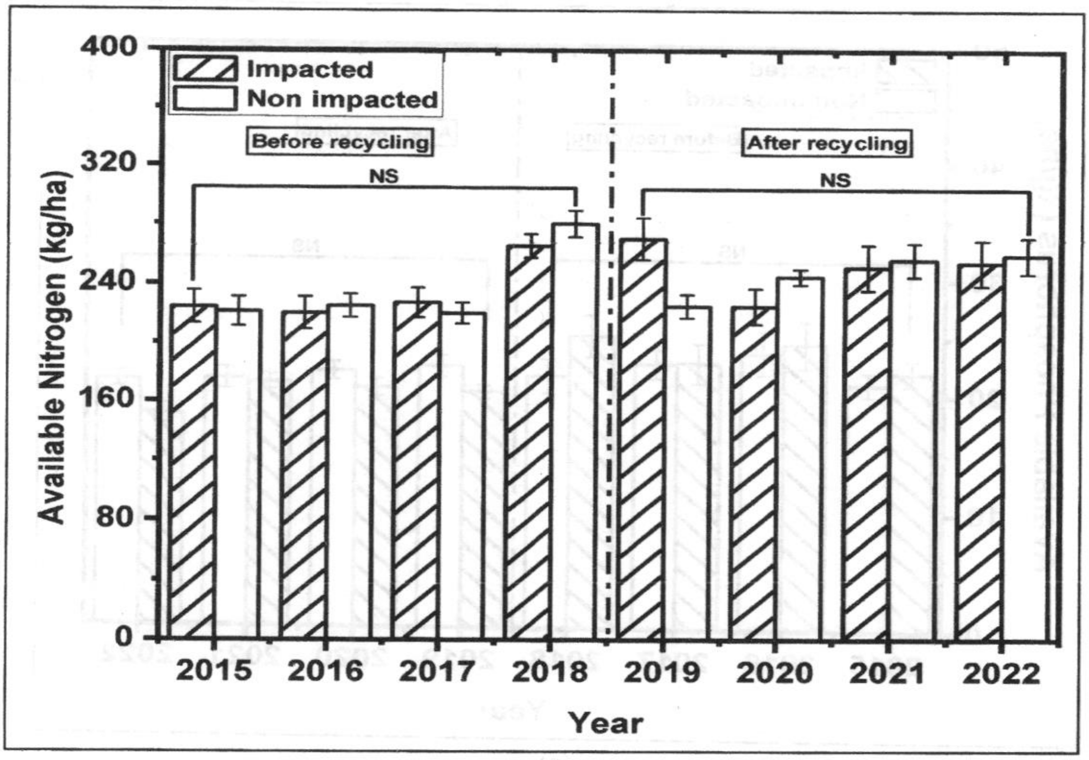
Impacted
Non impacted
Before recycling
After recycling
NS
NS
pH
0
2
4
6
8
10
12
14
2015
2016
2017
2018
2019
2020
2021
2022
Year

(a)



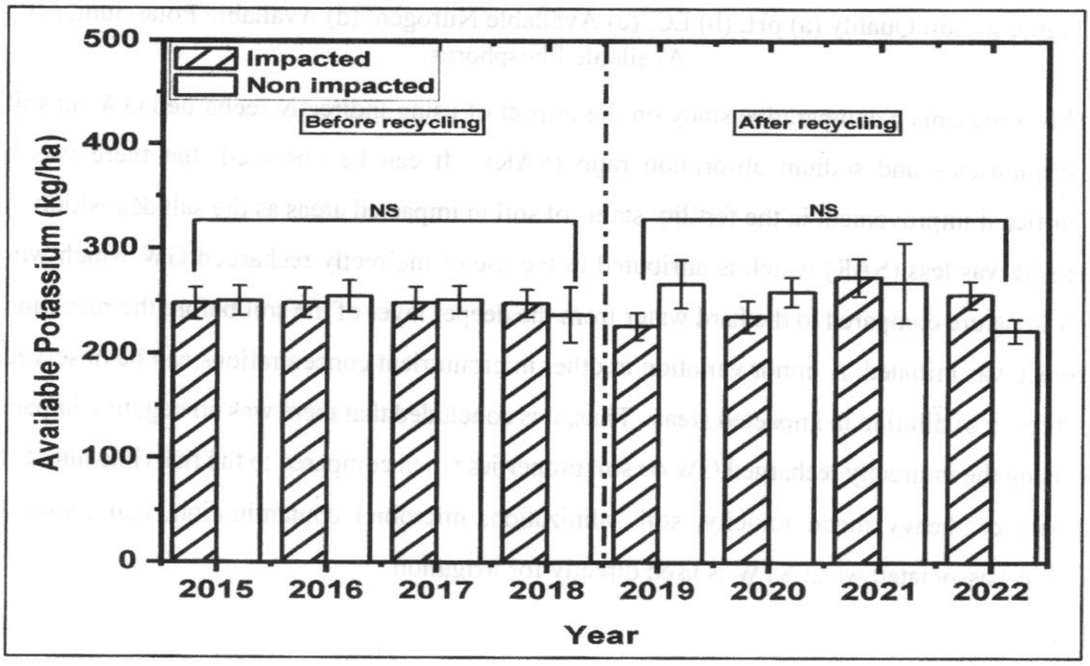
Impacted
Non impacted
Before recycling
After recycling
NS
**
EC (ds/m)
0.0
0.2
0.4
0.6
0.8
1.0
2015
2016
2017
2018
2019
2020
2021
2022
Year

(b)



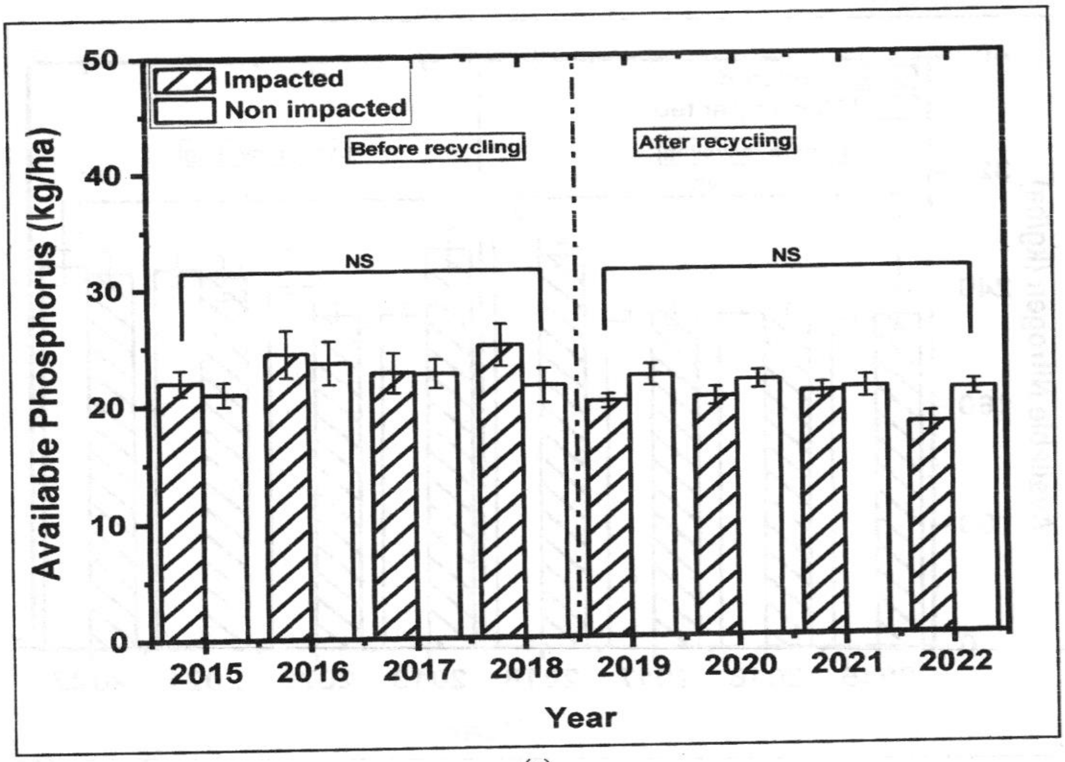
Impacted
Non impacted
Before recycling
After recycling
NS
NS
Available Nitrogen (kg/ha)
400
320
240
160
80
0
2015
2016
2017
2018
2019
2020
2021
2022
Year

(c)



Impacted
Non impacted
Before recycling
After recycling
NS
NS
Available Potassium (kg/ha)
500
400
300
200
100
0
2015
2016
2017
2018
2019
2020
2021
2022
Year

(d)



(e)

Figure 2: Soil Quality (a) pH, (b) EC, (c) Available Nitrogen, (d) Available Potassium, (e) Available Phosphorus

Table 3 presents a comparative study on the impact of using indirectly recharged GW on soil micronutrients and sodium absorption ratio (SAR). It can be observed that there was a significant improvement in the fertility status of soil in impacted areas as the salt deposition in the soil was less (SAR) which is attributed to the use of indirectly recharged GW which was soft in nature compared to the hard water from the deeper layer of the soil before the recycling project was initiated. A minor variation in other micronutrient concentrations can be observed as a result of dilution in impacted areas. Thus, it is concluded that there was no negative impact of using the indirectly recharged GW on soil properties when compared to the risk (like nutrient imbalance, heavy metal toxicity, soil salinization, microbial contamination, and reduced fertility) associated when STW is used directly for irrigation.

Table 3. Impact on micronutrient content and SAR of soils

S.No.	Parameters	Impacted Area		Non-impacted Area	
	(mg kg-^{1})	**Before recycling (2016-2018)**	**After recycling (2019-2022)**	**Before recycling (2016-2018)**	**After recycling (2019-2022)**
1.	Zinc	1.87 ± 0.09	1.05 ± 0.01	1.57 ± 0.2	1.77 ± 0.08
2.	Boron	1.59 ± 0.1	0.57 ± 0.06	1.82 ± 0.1	1.69 ± 0.2
3.	Iron	23.84 ± 1.2	11.62 ± 1.2	28.04 ± 2.2	24.55 ± 3.4
4.	Manganese	25.05 ± 1.6	18.68 ± 1.5	22.22 ± 1.8	25.01 ± 2.2
5.	Copper	1.4 ± 0.3	0.83 ± 0.01	1.9 ± 0.4	1.4 ± 0.01
6.	SAR (mEq/L)	5.7 ± 1.1	3.5 ± 0.9	5.5 ± 1.5	6.1 ± 1.8

Table 4 present microbiological load in soil. There was no considerable difference in the mean concentration of total coliform and *E. coli* in both impacted and non-impacted soil samples. It may be observed that non-impacted soil had only a marginally higher number of *E. coli* and total coliform in soil when compared with impacted soil, suggesting no significant impact of using indirectly recharged GW with STW on the microbial pathogen risks in cultivated soil. Since *E. coli* is one of the most important microbial indicators of fecal contamination, its presence in soil irrigated with non-impacted water could be due to any external environmental source of fecal contamination such as bird dropping, domestic animals, and open defecation (Edge and Hill, 2007). None of the marker pathogens studied (*Shigella, Klebsiella,*) were detected in soil samples.

Table 4. Microbiological load in soil

Sl.No.	Parameters	*E. coli* (CFU/g)	Total coliform (CFU/g)	*Shigella* (CFU/g)	*Klebsiella* (CFU/g)
1.	Impacted Soil	130 ± 5	1208 ± 20	N.D.	N.D.
2.	Non-impacted soil	144 ± 8	1330 ± 42	N.D.	N.D.

(Note: N.D.- Not detectable)

3.2 Soil health card of the experimental site

The health of the soil based on the parameters prescribed by the Indian Council of Agriculture Research (ICAR) and the Indian Institute of Soil Science (IISS) is presented in Table 5. It may be observed that most of the parameters such as available N, and available P fall under the medium category whereas available K falls under the higher category. Hence, it may be concluded that there was no significant difference in the soil health of the impacted and non-impacted areas confirming that there is no negative impact of irrigating agricultural fields with indirectly recharged GW and can be considered as a safe alternative for irrigation instead of using treated WW directly. After the commencement of the project due to the availability of water, farmers tended to cultivate cash and water-intensive crops (Tomato, ragi, paddy, carrot, cabbage, spinach, and fruits) over less water-intensive crops (Horse gram, ragi, and sometimes tomato if rainwater is available) (Manisha et al., 2023). A change in cropping pattern was also observed where in impacted areas farmers grew crops thrice in a year whereas in non-impacted areas once in a year.

Table 5. Soil health (GoI, 2017) based on parameters prescribed by ICAR and IISS

Sl.No.	Parameters	Impacted	Non-impacted
1.	Available N (High:>480 kg/ha; Medium: 240-480 kg/ha; Low: <240 kg/ha)	Medium	Medium
2.	Available K (High:>280 kg/ha; Medium: 110-280 kg/ha; Low: <110 kg/ha)	High	High
3.	Available P (High:>22 kg/ha; Medium: 11-22 kg/ha; Low: <11 kg/ha)	Medium	Medium

3.3 Bacterial diversity in soil

The dominant phylogenetic bacterial diversity and their specific role in the two soil samples (impacted and non-impacted) are presented in Table 6. A total of 14 bacterial phyla in common were observed in the two soil samples. *Proteobacteria* was the most abundant community (28–30%), followed by *Bacteroidetes* (10–15%), firmicutes (13-15%), *Acidobacteria* (12-15%), *Actinobacteria* (6-8%), *Planctomycetes* (6–7%), *Chlorofexi* (6–7%), *Verrucomicrobia* (2–3.5%), *Gemmatimonadetes* (1- 4.5%), *Nitrospirae* (1.5–2%) and few were the other groups. As seen from Table 1, there was no significant difference in the bacterial community concentration when compared in the two samples except for *Gemmatimonadetes* which are high in non-impacted soil as these are more prevalent in dry soils (DeBruyn et al., 2011). This indicates that the use of indirectly recharged GW for irrigation in impacted areas has no adverse effects on bacterial diversity. It can be observed from the role of the dominant phyla presented in Table 2 that most of them are plant growth promoters, few are major members in the nitrogen fixation cycle, few of them facilitate phosphorus and other micro-nutrient solubilization, few are involved in energy production and C metabolism, few of them secrete biofumigants and are associated in disease suppression by targeting pathogens (Malisorn et al., 2020; Li et al., 2020; Sharma and Salwan, 2018; Bruto et al., 2014). The outcomes of our study are in agreement with similar other studies (Ibekwe et al., 2018; Broszat et al., 2014) that have reported no significant impact on the overall diversity and richness of bacteria (depending on the quality of the treated WW) between soil irrigated with treated WW and synthetic freshwater. Table 6 also presents the comparison of phylogenetic bacterial diversity in soil when direct STW is used for irrigation.

Table 6. Soil health (GoI, 2017) based on parameters prescribed by ICAR and IISS

Sl. No.	Phylum	Impacted soil	Non-impacted soil	Secondary treated WW (Ibekwe et al., 2018)	Role	Reference
1	Proteobacteria	30.6% ± 5.4	28.2% ± 6.8	32.1% ± 5.1	• Plant growth-promoters (rhizobacteria) • Nitrogen fixation • Helps in phosphate and zinc solubilization • Produce Indole-3-acetic acid	• Malisorn et al., 2020
2	Bacteroidetes	14.7% ± 3.3	11.6% ± 2.7	1.62% ± 0.1	• Secrete diverse arrays of carbohydrates and active enzymes • Participate in energy production and conversion	• Lidbury et al., 2021
3	Firmicutes	14.2% ± 2.8	13.0% ± 1.4	26.5% ± 6.2	• Involved in cell wall biosynthesis • They are important chitinolytic bacteria • Play a role in the bio-control of plant pathogens in the phytoremediation of heavy metals	• Sharma and Salwan, 2018
4	Acidobacteria	14.3% ± 1.7	12.0% ± 3.0	3.1% ± 0.4	• Growth-promoting bacteria • Produce exopolysaccharides and modulate plant hormone level • Facilitate nitrogen, phospherous, and iron acquisition	• Kielak et al., 2016
5	Actinobacteria	7.5% ±0.7	6.3% ± 1.8	14.3 ± 3.1	• Helps to solubilize phosphorus and potassium • Major role in nutrient cycling	• Li et al., 2020

					• Increase growth yield of staple crops like tomato • Potential destroyer of fungi and other bacteria that cause damage to plants • Associated with disease suppression	
6	Planctomycetes	6.7% ± 2.1	7.1% ± 1.4	0.8 ± 0.0	• Major role in the nitrogen cycle as can oxidize ammonia to dinitrogen without oxygen.	• Fuerst and Sagulenko, 2011
7	Chloroflexi	6.2% ± 1.4	7.0% ± 1.1	-	• Filamentous bacteria • Ferment carbohydrates and degrade other complex organic compounds	• Lidbury et al., 2021
8	Verrucomicrobia	3.4% ± 1.8	2.2% ± 0.5	0.19 ± 0.0	• Role in lipopolysaccharide biosynthesis and C metabolism	• Li et al., 2020
9	Gemmatimonadetes	1.0% ±0.3	4.2% ± 1.3	0.07 ± 0.0	• Important role in the cycling of organic C due to their metabolic strategies • These are more prevalent in drier soils	• Kielak et al., 2016
10	Nitrospirae	1.9% ± 0.2	1.6% ± 0.2	-	• Plays an important role in nitrification as a nitrite-oxidizing bacteria • Also provide ammonic oxidizers	• Fuerst and Sagulenko, 2011
11	Armatimonadetes	1.7% ± 0.4	1.4% ± 0.4	-	• No major role	• Lidbury et al., 2021
12	Crenarchaeota	0.1% ± 0.0	1.6% ± 0.1	-	• Involved in nitrogen cycle for ammonia oxidation	----
13	0D1	0.2% ± 0.0	1.2% ± 0.1	-	• No major role	----
14	WS3	0.1% ± 0.0	1.1% ± 0.0	-	• No major role	----

3.4 Microbial Load on crop

The use of wastewater (WW) for irrigation raises significant concerns regarding foodborne diseases linked to the consumption of contaminated produce. The indirect recharge of GW using STW was a concern for the contamination of crops. The microbial load of crops irrigated with indirectly recharged GW and non-impacted GW is presented in Table 7. It may be observed that none of the crop samples studied (except for spinach) contained detectable total coliforms, *E. coli* (an indicator of fecal contamination), and pathogens (*Shigella,* and *Klebsiella,*) suggesting no risk of infection on consuming these crops. As discussed earlier, the time between water being filled in the tanks and reaching GW recharge state can be as low as 1.5 years and this is far too long for pathogens to survive. It can be observed that a few total coliforms were detected on spinach (leafy vegetables) in both impacted and non-impacted areas suggesting human handling to be the major route rather than irrigation water. Hence, it is always recommended to wash and cook green leafy vegetables before direct consumption as they are most susceptible to bacterial contamination (Sinha et al., 2010). Consistent with our results, Orlofsky et al. 2016 showed no significant difference in the detection of fecal indicator bacteria on tomatoes irrigated with treated WW as compared with tomatoes irrigated with potable water. Farhadkhani et al. 2018, also detected a few of the selected pathogens in SWW and irrigated soils, but none of the tested plant samples were positive for the studied pathogens. Similar results were reported about the microbial quality of eggplant and tomatoes drip irrigated with treated WW (Cirelli et al., 2012).

Table 7: Microbiological load on crops

Sl. No.	Crop type	Total coliform (CFU/mL)		*E.Coli* (CFU/mL)		*Shigilla* (CFU/mL)		*Klebsiella* (CFU/mL)	
	Type of Water for irrigation	IRGW	NIGW	IRGW	NIGW	IRGW	NIGW	IRGW	NIGW
1.	Beetroot	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2.	Tomato	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
3.	Spinach	200	480	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

(Note: N.D.- Not detectable. IRGW: Indirectly Recharged Groundwater; NIGW: Non-impacted Groundwater)

Conclusion:

The utilization of direct wastewater for irrigation poses many environmental problems such as soil quality deterioration due to the accumulation of salts, heavy metals, micro-pollutants and health risk due to undesirable microorganisms. This hampers its agricultural reuse in arid and semi-arid regions. To address these concerns, the present study introduces a recent approach that involves using indirectly recharged groundwater (GW) with secondary treated municipal wastewater (STW) for irrigation through a Soil Aquifer Treatment-based system (SAT). This method aims to mitigate freshwater scarcity in semi-arid regions. The outcomes of the study indicated no negative impact on soil properties when using indirectly recharged GW whereas a positive significant impact was reduced soil salinity in impacted areas. No microbial contamination in terms of pathogens was found on tested soil and crop samples. Hence, indirectly recharged GW using STW could be safely used as an alternative source for irrigation overcoming the concerns of heavy metals, micro-contaminants and pathogens associated with the direct use of partially treated or untreated mixed municipal WW for irrigation.

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29th of September 2025

Assessing the Impact of Indirect Groundwater Recharge through Recycled Water on Public health in KC Valley Project

To
The Executive Engineer
Kolar Division
MI Department
Bangalore
Karnataka

Dear Sir,

Further to your request, I am sharing with you the findings on the human health survey data we obtained from Directorate of Health and Family Welfare Service, Kolar to understand if any changes in disease patterns after implementation of project

Please do let me know if you have any other questions

Best Regards

Dr. Lakshminarayana Rao
CST, IISc

Assessing the Impact of Indirect Groundwater Recharge through Recycled Water on Public health in KC Valley Project

1. **Objective:**

This study aims to quantify the impacts of water recycling project for indirect GW recharge on public health.

2. **Methodology**

To obtain the study's objectives quantitative data were collected and comprehensively analyzed. To assess the prevalence of diseases in the Kolar district over the past nine years (2015-2023), quantitative data was obtained from the Directorate of Health and Family Welfare Service, Kolar to understand if any changes in disease patterns after implementation of project, particularly waterborne diseases.

3. **Result**

3.1 Analysis of public health data received from health departments, Kolar

Data received from the Directorate of Health and Family Welfare Service, Kolar, Government of Karnataka, indicates a comprehensive overview of the prevalence of waterborne, and water-related, diseases in the Kolar Taluka which is one of the impacted areas. The ten identified diseases include diarrhea-gastroenteritis, typhoid, bacillary dysentery, viral hepatitis, leptospirosis, Japanese encephalitis, malaria, dengue, chikungunya, and skin diseases.

Summary of the findings

- Total prevalence of diseases reduced by 67% from 11012 cases during pre-recycling period to 3627 during post-recycling period. This is attributed to increased hygiene practices due higher availability of the water
- Typhoid fever cases decreased by 85% from 673 to 100.
- Bacillary dysentery cases decreased by 70% from 588 to 174.
- Diarrhea-gastroenteritis cases decreased by 67% from 9312 to 2990.
- Viral hepatitis-A cases reduced by 53% from 83 to 39.
- Leptospirosis decreased by 53% from 63 to 29.
- Skin diseases includes rashes, eczema, blisters, redness, itching reduced by 10% from 150 to 135.
- Malaria cases decreased by 57% from 7 to 2.
- Dengue did not indicate a distinct increase or decrease pattern, during both period average cases was 70.

4. **Conclusions**

Based on data collected in this study from the Directorate of Health and Family Welfare Services, Government of Karnataka, the analysis indicates that the reuse of secondary treated wastewater for indirect groundwater recharge through the Soil Aquifer Treatment technique does not adversely affect public health. On the contrary, improvements in hygiene and WASH scores were observed, as evidenced by the decline in waterborne diseases. This positive outcome can be attributed to better water availability, improved sanitation and hygiene practices, and enhanced nutritional intake. In the context of growing water scarcity, particularly in semi-arid regions, decision-makers should prioritize and support projects that strengthen water security through sustainable water reuse. Overall, this study recommends that policymakers actively promote the reuse of treated wastewater for indirect groundwater recharge.

Water Quality Analysis

Report

भारतीय विज्ञान संस्थान

Submitted By:

CST, IISc Bengaluru

8th August 2025

Water Quality Analysis

IISc Bengaluru under the K&C Valley project has been periodically monitoring the water quality of STP effluent. The water quality of the analysed STP effluent between January 2025 to June 2025 is presented in Table 1 and Table 2:

Table 1: Water quality of STP final treated effluent

Sl. No.	Parameters	Unit	Hon'ble NGT discharge standards (NGT, 2019)	STP Outlet/DC Point					
				25-Jan	25-Feb	25-Mar	25-Apr	25-May	25-Jun
1	pH	-	6.5-9.0	7.2	7	7	7.2	7.2	7.4
2	BOD5 (@20 °C)	mg/L	10	3.7 ± 0	4.5 ± 0	6.4 ± 0	8.3 ± 0	15.6 ± 0	2 ± 0
3	COD	mg/L	50	24 ± 2.8	42 ± 5.7	37 ± 5.5	39 ± 1.4	40 ± 2.7	NA
4	TSS	mg/L	10	8 ± 1	9 ±1	5 ± 1.5	8 ±1	9 ± 1	10 ± 1
5	NH_4 -N	mg/L	5	1.14 ± 0.07	0.39 ± 0.03	0.04 ± 0.02	1.71 ± 0.15	4.9 ± 0.08	8.1 ± 0.09
6	TN	mg/L	10	8 ± 2	9 ± 1	6 ± 3	10 ± 2	9 ± 1	NA
7	PO_4- P	mg/L	1	1.3 ± 0	1.3 ± 0	1.3 ± 0.1	0.6 ± 0	0.7 ± 0	0.6 ± 0
8	Faecal Coliform	MPN/100 mL	< 230 allowable	>230	>230	>230	>230	>230	>230
NA = Not available									

Remarks

- The water quality at the DC points meets the Honorable NGT standards for all parameters except for E-coli.

Table 2: Water quality (heavy metals) of STP final treated effluent

Sl.No.	Metals, metalloids, and heavy metals	IS 10500 (mg/L) (BIS 10500, 2012)	Secondary treated wastewater (mg/L)
1	Iron (Fe)	3	0.36 ± 0.02
2	Manganese (Mn)	2	0.02 ± 0
3	Zinc (Zn)	5	BDL ± 0
4	Cadmium (Cd)	2	BDL ± 0
5	Lead (Pb)	0.1	BDL ± 0
6	Arsenic (As)	0.2	0.001 ± 0
7	Chromium (Cr^{+5})	0.1	<0.1 ± 0
8	Nickel (Ni)	3	0.028 ± 0
9	Copper (Cu)	3	0.00 ± 0
10	Aluminium (Al)	0.2	BDL ± 0
11	Barium (Ba)	0.7	0.045 ± 0
12	Boron (B)	0.5	0.021 ± 0
13	Selenium (Se)	0.01	BDL ± 0
14	Silver (Ag)	0.1	BDL ± 0
15	Mercury (Hg)	0.001	BDL ± 0
16	Molybdenum (Mo)	0.07	0.001 ± 0

Note: *BDL is below the detection limit of* $1x10^{-6}$ *mg/L*

Remarks

- The heavy metals are not detected in the STP final treated water reaching at the DC point of Kolar. In fact, the heavy metal levels are meeting drinking water standards IS10500:2012

Water Quality Analysis

Report

Submitted By:

CST, IISc Bengaluru

8th August 2025

Sampling and Analysis

IISc Bengaluru under the K&C Valley project has been periodically monitoring the surface water quality of lakes, and groundwater quality. Impact on groundwater levels is also analysed by collecting historical and present data. The analysis outcomes are presented below:

Table 1: Surface Water quality (March 2025)

Parameters (mg/l)	[1] Hon'ble NGT Standard	[2] CPCB (Designated-Best-Use water quality)	Impacted		Non-Impacted	
			Narsapura tank (mg/L)	Chowdenhalli tank (mg/L)	Imarakunte tank (mg/L)	Byappanahalli tank (mg/L)
pH*	6.5-9.0	6.5-8.5 B, D, E	7.4	7.5	6.7	7.2
BOD5	10	(@20°C) ≤3mg/l B	6.5 ± 0.4	3.0 ± 0.3	5.4 ± 0.4	3.8 ± 0.1
COD	50	-	46 ± 4.0	41 ± 6.0	59 ± 8	45 ± 4
TSS	10	-	6 ± 0.3	7 ± 0.1	25 ± 0.2	15 ± 1
N-total	10	-	8 ± 0.8	7.3 ± 0.5	9 ± 0.2	7 ± 0.3
NH_4-N	5	1.2 D	1.2 ± 0.0	0.8 ± 0.1	1.2 ± 0.2	0.6 ± 0.0
Fecal Coliforms (MPN/100ml)	>230	>500 B	230 ± 28	380 ± 31	520 ± 44	730 ± 25
PO_4-P	1	NS	0.4 ± 0.0	0.6 ± 0.0	0.03 ± 0.0	0.1 ± 0.0
DO	NS	≥6A,≥5B,≥4C,D	6.2 ± 0.1	7.8 ± 0.2	5.8 ± 0.1	6.1 ± 0.1
EC (@25°C,µs/cm)	NS	2250	824 ± 18	726 ± 22	869 ± 15	655 ± 25
SAR (mEq/l)	NS	26E	4.2 ± 0.5	3.6 ± 0.1	5.1 ± 0.2	3.2 ± 0.0
B	NS	2E	0.05 ± 0.0	0.02 ± 0.0	0.04 ± 0.2	0.01 ± 0.0

[1] NGT standard ,2019; [2] Designated_Best_Use_Water_Quality_Criteria.pdf (cpcb.nic.in)

*Note: B-Outdoor Bathing; D-Propagation of Wildlife and Fisheries; E-Irrigation, Industrial Cooling, Controlled Waste disposal. SAR-Sodium Absorption Ratio; DO- Dissolved Oxygen. *pH is unitless*

Remarks

- The impacted tanks surface water quality meets the Honouralbe NGT standards for all parameters except E-coli
- The impacted tanks surface water quality is better than the rain fed non impacted water quality

Table 2: Surface water quality (heavy metals) (March 2025)

Sl.No.	Heavy metals	IS 10500 (mg/L) (BIS 10500, 2012)	Impacted		Non-Impacted	
			Narsapura tank (mg/L)	Chowdenhalli tank (mg/L)	Imarakunte tank (mg/L)	Byappanahalli tank (mg/L)
1	Iron (Fe)	3	0.11 ± 0.02	0.21 ± 0	0.05 ± 0.0	0.16 ± 0.0
2	Manganese (Mn)	2	0.02 ± 0	BDL ± 0	BDL ± 0	BDL ± 0
3	Zinc (Zn)	5	0.01 ± 0	BDL ± 0	0.01 ± 0	BDL ± 0
4	Cadmium (Cd)	2	BDL ± 0	BDL ± 0	BDL ± 0	BDL ± 0
5	Lead (Pb)	0.1	BDL ± 0	BDL ± 0	BDL ± 0	BDL ± 0
6	Arsenic (As)	0.2	0.006 ± 0	0.001 ± 0	0.002 ± 0	0.001 ± 0
7	Chromium (Cr^{+5})	0.1	0.02 ± 0	0.01 ± 0	0.01 ± 0	0.01 ± 0
8	Nickel (Ni)	3	0.014 ± 0	0.0 ± 0	0.01 ± 0	0 ± 0
9	Copper (Cu)	3	0.007 ± 0	0 ± 0	0.004 ± 0	0 ± 0
10	Aluminium (Al)	0.2	0.05 ± 0	0 ± 0	0.07 ± 0	0 ± 0
11	Barium (Ba)	0.7	0.01 ± 0	0.01 ± 0	0.03 ± 0	0.01 ± 0
12	Selenium (Se)	0.01	0.02 ± 0	BDL ± 0	0.01 ± 0	BDL ± 0
13	Silver (Ag)	0.1	BDL ± 0	BDL ± 0	0.001 ± 0	BDL ± 0
14	Mercury (Hg)	0.001	BDL ± 0	BDL ± 0	BDL ± 0	BDL ± 0
15	Molybdenum (Mo)	0.07	0.004 ± 0	BDL ± 0	0.007± 0	BDL ± 0

Note: *BDL is below the detection limit of $1x10^{-6}$ mg/L*

Remarks

- The heavy metals are not detected in the surface water of both impacted and non-impacted tanks. The heavy metal levels are meeting drinking water standards IS10500:2012

Table 3. Groundwater Quality (March 2025)

Parameters	Pre recharge (2014- 2018)	Post recharge (2019-2024)	Student's t-test value
pH	7.8	7.6	1.6 ^{NS}
EC (µs/cm)	2500 ± 26	421 ± 5	4.6*
Hardness (mg/L)	850 ± 12	145 ± 15	6.6**
TDS (mg/L)	1500 ± 22	380 ± 10	6.5**
Cl- (mg/L)	600 ± 15	40 ± 6	5.3**
SAR (meq/L)	32 ± 6	6 ± 0	4.9**

Note: Data source (Narsapura Borewell): Central Ground Water Board (CGWB), and Karnataka State Pollution Control

Remarks

- The groundwater quality post KC valley project has significantly improved for all the parameters.

Table 4. Groundwater quality (Heavy metals) (March 2025)

Sl.No.	Metals, metalloids, and heavy metals	IS 10500 (mg/L)	Groundwater (mg/L)
1	Iron (Fe)	0.3	0.6
2	Manganese (Mn)	0.1	0.0
3	Zinc (Zn)	5	BDL
4	Cadmium (Cd)	0.003	BDL
5	Lead (Pb)	0.1	BDL
6	Arsenic (As)	0.01	BDL
7	Chromium (Cr+5)	0.05	BDL
8	Nickel (Ni)	0.02	0.008
9	Copper (Cu)	0.05	0.0
10	Aluminium (Al)	0.2	BDL
11	Barium (Ba)	0.7	BDL
12	Boron (B)	0.5	0.001
13	Selenium (Se)	0.01	BDL
14	Silver (Ag)	0.1	BDL
15	Mercury (Hg)	0.001	BDL
16	Molybdenum (Mo)	0.07	0.0

Note: *BDL is below the detection limit of $1x10^{-6}$ mg/L*

Remarks

- The heavy metals are not detected in the groundwater of impacted tanks. The heavy metal levels are meeting drinking water standards IS10500:2012

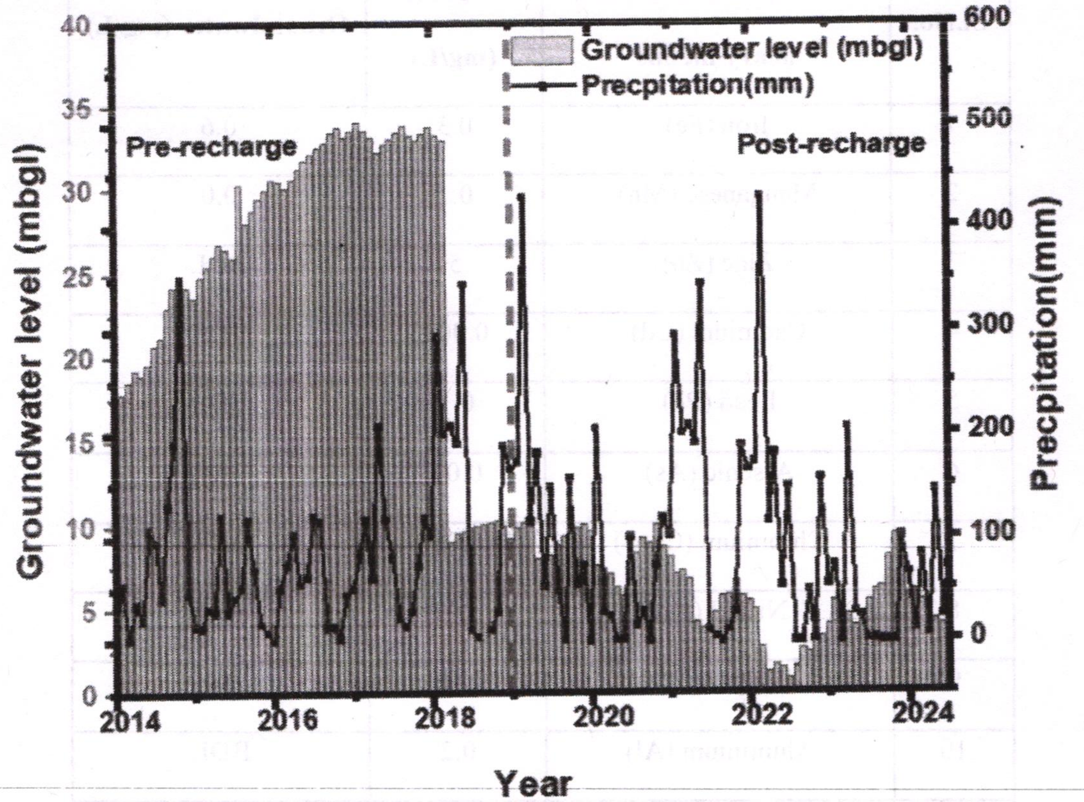

Fig 1. Impact of indirect groundwater recharge on groundwater level (Kolar borewell)

Data source: the Department of Karnataka Ground Water Authority (KGWA) and Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Govt. of Karnataka, India.

Remarks

- Figure 1 shows that after post KC valley project the groundwater levels have significantly improved.

ಅನುಬಂಧ-2

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08th of November 2023

To
The Chief Engineer,
Minor Irrigation and Ground Water Department (South)
Bangalore Karnataka

Dear Sir

Ref

1) AEE/MI&GWD Sub Varthur /K&C Valley/ 2023-24/224 dated 07-11-2023
2) "Environmental Impact Assessment of KC Valley Project", Agreement No 134/2019-20 dated 02/03/2020
3) Interim report submitted by CST-IISc dated 21-01-2022
4) No:AEE/MI&GWD Sub Varthur /K&C Valley/ 148/2023-24 dated 31-07-2023

With respect to the above reference, we would like submit the following

IISc team is monitoring/measuring heavy metals periodically in K & C valley project. Table 1 below lists the date/location of water sampling and the important findings. The drinking water specification IS 10500: 2012 lists 18 metals out of which 6 are listed as toxic heavy metals. In the secondary treated water from the STPs of K & C valley and Bellandur, all these 18 metals are well below the acceptable limits from the multiple samples collected between 2019 to 2022 (please note this **meets even the stringent drinking water standards**). Hence this water, when used for indirect recharge, is not expected to cause any heavy metal pollution of the underground water table.

Table 1: Heavy Metals Measured in K & C Valley Project

Sl No	Date of Sample	Location	Remarks	Details
1	10th Jan 2019	10 locations including K&C valley	The secondary treated water which is being pumped to Kolar from STP at K & C Valley and Bellandur does not	Annexure I

		STPs and Tanks in Cluster 1	contain any harmful heavy metals above the prescribed limit and even meets drinking water Standards IS 10500: 2012	
2	10th Jan 2020	All five inlets to Bellandur Lake and outlet of Bellandur Lake	Heavy metals even in untreated wastewater entering Bellandur lake from all five inlets and even the Bellandur lake outlet is within the prescribed limit even for drinking water Standards IS 10500: 2012. The wastewater undergoes anaerobic conditions during which all of them will precipitate out even if present.	Annexure -II
3	15th of March 2021	Raw sewage entering K&C valley STP and Secondary Treated water pumped to Kolar	The heavy metal concentrations in secondary treated water which is being pumped to Kolar from STP at K & C Valley and Bellandur are well below even the drinking water Standards IS 10500: 2012	Annexure -III
4	5th October 2021	DC point, Narasapura Tank, open well, borewell and Kalyani near Narsapura Tank	The secondary treated water which is being pumped to Kolar from STP at K & C Valley and Bellandur does not contain any harmful heavy metals above the prescribed limit as per drinking water Standards IS 10500: 2012 (meets even the drinking water standards) Even the groundwater in borewells, open wells and Kalyani near Narsapura Tank does not contain any harmful heavy metals above the prescribed limit as per drinking water Standards IS 10500: 2012	Annexure -IV
5	20th of July 2022	DC point and Lakshmisagar Tank Outlet	The secondary treated water which is being pumped to Kolar from STP at K & C Valley and Bellandur does not contain any harmful heavy metals above the prescribed limit as per drinking water Standards IS 10500: 2012 (meets even the drinking water standards)	Annexure -V

As can be seen from Table 1, the secondary treated water which is being pumped to Kolar from STP at K & C Valley and Bellandur does not contain any harmful heavy metals above the prescribed limit **even as per drinking water Standards IS 10500: 2012**.

Also, IISc has clearly demonstrated that thermodynamically, any heavy metal will have the propensity to precipitate as sulphides and form insoluble salts very rapidly, thus rendering the wastewater free from heavy metals, which is published in Current Science Article, given here as Annexure VI.

Also, IISc has regularly published this data on absence of heavy metals in groundwater and surface water samples impacted by K&C valley project and secondary treated water being pumped to Kolar through various publication attached here as Annexure VII and Annexure VIII.

Sincerely

Dr. Lakshminarayana Rao
CST, IISc

Prof. H N Chanakya
CST, IISc

Prof. M S Mohan Kumar
(Former Prof.) CE, IISc

1. Copy to Secretary, Minor Irrigation& Groundwater development Department, Government of Karnataka, Vikasa Soudha, Bangalore for information.
2. Copy to Superintending Engineer, Minor Irrigation Circle, Bangalore for information.
3. Copy to Executive Engineer, Minor Irrigation Division, Kolar for information and necessary action.
4. Copy to AEE MI subdivision Varthur for necessary action.

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7th of March 2019

A note on STP secondary treated water quality of K and C Valley and Bellandur

Background This project is about supplying secondary treated domestic sewage water to tanks of Kolar for indirect recharge of underground water. In this project, secondary treated sewage water is directly picked up from the plant and passed on to pipe at K& C valley and Bellandur and thus the situation of getting mixed up with existing Lake waters at Bellandur does not arise. This is one of the unique projects where a Mega City (which is normally seen as guzzler of water and energy) becomes a source for indirect ground water recharge and irrigation in neighboring towns / villages and peri urban areas thus supporting their livelihood ecology / environment and other activities. There is a UN mandate on use of right quality of water for right purpose indicating necessity for minimal treatment which is enough for the purpose. Treated Water as it flows from one tank to the other, the quality of such waters will improve since it will be exposed to oxygenation and sunlight. Mixing with local catchment waters, the quality will only improve, if no local waste water flows in. Moisture build up will happen surrounding the tank areas which will help in agriculture. Need based, small quantity water could be treated to the drinking water standards

- In India, there are no water quality standards for such applications i.e., indirect recharge from secondary treated waters. However, based on the water quality testing that has been done as per the submitted report titled "Report of Secondary Treated Water Quality from K & C valley, Bellandur STP and tanks in Kolar", dated 21st Jan 2019 and the final report dated 7th of March 2019, the secondary treated water from K & C valley and Bellandur STP meets:
  - the water quality criteria for irrigation as per IS:11624-1986, BIS Standard.
  - the water meets the Class E criteria as per "DESIGNATED BEST USE CLASSIFICATION OF STREAMS', of CPCB, which is for Irrigation and industrial cooling.'

- In most of the cases, the Water Quality satisfies, Class D which is fit for Aquaculture as well
- Based on the water analysis result presented as per the above said report, this secondary treated water from the K & C valley and Bellandur STP can be safely used for indirect recharge of underground water and Irrigation purposes.

- Water which is fit for irrigation purposes is certainly fit for indirect recharge of underground water.
- The drinking water specification IS 10500: 2012 lists 18 metals out of which 6 are listed as toxic heavy metals. In the secondary treated water from the STPs of K & C valley and Bellandur, all these 18 metals are well below the acceptable limits. Hence this water, when used for indirect recharge, is not expected to cause any heavy metal pollution of the underground water table.
- Heavy metals in the treated water from the treatment plant are well below the acceptable limits for drinking water and hence of no serious threat is likely to human / animal life from these heavy metals.
- During the indirect recharge, it is well understood that the water percolates slowly through the torturous pores through multilayers of the Mother Earth. During this process of slow percolation, it is well understood that the water quality improves even further as it trickles down through such soil layers.
- As the above observations are based on a single grab sample taken on 10th of Jan 2019, in order to get a better control of the system, it is suggested that periodic monitoring, lab testing, documentation and reporting mechanism needs to be implemented through any credible third-party observers.
- Several Institutes / research labs / regulatory authorities have tested the quality of secondary treated waters and have come with similar opinion that it meets the required standards.
- If need be, once the plant starts running, again, the quality of secondary treated waters could be ascertained by National Labs Institutes of high repute such as IISc and NEERI.

Lakshminarayana Rao
Date : 7th of March 2019

H N Chanakya
Date : 7th of March 2019

Report of Secondary Treated Water Quality from K & C valley, Bellandur STP and tanks in Kolar

1. INTRODUCTION

The Minor Irrigation Department has implemented a project for pumping secondary treated water from the STP at K &C Valley and Bellandur to fill 126 tanks in Kolar District. On 9th January 2019, the Minor Irrigation department approached IISc to sample the secondary treated water which is pumped to tanks in Kolar. On 10th of January 2019, IISc team undertook a water quality sampling campaign and have collected ten (10) water samples from various locations as listed in Table 1. The water quality is being accessed at IISc. IISc team of professors, consisting of Prof H N Chanakya and Dr Lakshminarayana Rao have analyzed the samples collected and a report is prepared. The details of the same are described below.

Table 1: Summary of water samples collected

Sl. No	Water Sampling Location	Sample Identification #
1	K & C valley STP - Before chlorine contact tank	1
2	K & C valley STP - After chlorine contact tank (Lift Point 1)	2
3	Bellandur STP after Chlorination tank (Life Point 2)	3
4	Discharge point Lakshmisagar Lake (first drop point into Kollar tanks)	4
5	Lakshmisagara waste weir (Outlet from Lakshmisagar lake)	5
6	Udapanahalli tank-1 (First lake downstream of Lakshmisagar lake)	6
7	Udapanahalli waste weir-2 (outlet from Udapanahalli Lake)	7
8	Narsapura tank	8
9	Doddavalabhi waste weir	9
10	Signahalli tank	10

2. WATER QUALITY OF SAMPLES COLLECTED

Table 2 lists water quality parameters analyzed of the water samples collected and Table 3 lists the test methods followed to analyze each parameter. Based on the results of the analysis the following conclusions are drawn and recommendations are made.

- Based on the water analysis, the water quality meets the water quality criteria for irrigation as per IS:11624-1986, BIS Standard (Annexure I).
- Based on the water analysis, as presented in Table 2, the water meets the Class E criteria as per "DESIGNATED BEST USE CLASSIFICATION OF STREAMS', of CPCB, which is for 'Irrigation and industrial cooling' (Annexure II). This water pumped to the tanks of Kolar can be safely used for Irrigation purposes.
- As India does not have any specific standards for indirect ground water recharge i.e., percolation through the soil strata and as recharged ground water is mostly used for irrigation purposes in Kolar, as indicated above, it meets the criteria for irrigation through ground water as the designated best use.
- In addition, the water quality of the all the water samples analyzed, for all the measured parameters as shown in Table 2, also meets a much stringent criteria as per the CPCB Inland surface water standards (Annexure I). The results indicate that the secondary treated water which is being pumped to Kolar from STP at K & C valley and Bellandur does not contain any harmful heavy metals above the prescribed limit.
- Also, the secondary treated water which is being pumped from STP at K & C valley and Bellandur i.e., sample 2,3 and 4 meet the Class D criteria as per "DESIGNATED BEST USE CLASSIFICATION OF STREAMS', of CPCB, which is for 'propagation of wild life and fisheries' (Annexure II).
- The above results are based on a single grab sample taken on 10th of Jan 2019. In order to get a better control of the system, it is suggested that periodic monitoring, lab analysis, documentation and reporting mechanism needs to be implemented.

Dr H N Chanakya

Dr Lakshminarayana Rao

Date : 7th of March 2019