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Assessment of the Health Impacts of Sewage Water Irrigation on Agricultural Workers

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Abstract

Wastewater can be explored as an alternative water resource for irrigation in arid and semi-arid areas. In addition to conserving surface and subsurface water resources, the safe use of treated sewage water can increase crop yields. Despite numerous studies on wastewater irrigation, relatively limited research has been undertaken on the health impacts of wastewater irrigation on agricultural workers was undertaken. Many regions lack robust health monitoring systems for agricultural workers, making it difficult to assess the long-term health impacts of wastewater exposure. There is an urgent need to explore impacts of wastewater irrigation on farmworkers' health. It is of an utmost importance to consider advantages as well as the risks of wastewater irrigation to public health and the environment. With this objective, experiments focusing on sewage water reuse for the irrigation of Wheat and Green gram crops were conducted at the Campus of Nirma University, Ahmedabad. The study design took into account several treatments based on the use of sewage water, groundwater, and surface water in various blending ratios. The design of the studies also takes into account different treatments based on the application of nitrogenous fertilizer to soils. A total of three replications were performed for all experiments for wheat & green gram crops. The methodology involves assessing the health impacts on agricultural workers as a result of their exposure to pathogens associated with wastewater. The impacts on public health under said treatments are analyzed and discussed in the paper. Lead levels, Total Bilirubin, Conjugated Bilirubin, Unconjugated Bilirubin, SGPT, Polymorphs, Lymphocytes, Eosinophils, Monocytes and Basophils were found to be within the normal range in agricultural workers associated with sewage water irrigation for wheat and green gram crops.

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Introduction

It is the need of the hour to practice the safe reuse of wastewater to conserve freshwater resources and satisfy water demand.[1] Reusing municipal wastewater has emerged as a desirable alternative for boosting water supplies in these regions.[2] Because it may enable the expansion of intensive agriculture while maintaining the limited supply of high-quality drinking water for the rapidly growing metropolitan areas in most parts of the world, the reuse of wastewater for agricultural uses may be especially attractive. According to the regulatory viewpoint of urban, public health, or environmental authorities who prioritise the preservation of environmental quality and public health, wastewater irrigation should be implemented.[3,4] Since wastewater contains a potentially harmful load of pathogenic microorganisms that could infect humans, public health issues must be given top priority when planning wastewater reuse.[5,6,7] Wastewater irrigation can expose agricultural workers to multiple health risks due to the contaminants present in wastewater. The presence of pathogens may cause gastrointestinal infections from direct contact with contaminated water or crops and skin infections or dermatitis due to prolonged exposure to wastewater during irrigation activities. Any wastewater reuse scheme must have health standards set early on in the planning process to make sure that the advantages of having more water resources aren't outweighed by unjustified hazards to the public's health and the health of agricultural workers. Under these perceptions, it is very essential to determine effects on said workers associated with wastewater irrigation. The present study focuses on exploring heath impacts on agricultural workers who were exposed to wastewater irrigation.

Materials and Methods

With a view to conserving surface & groundwater resources, promoting safe reuse of sewage water in wheat & green gram production and study the impacts of waste water irrigation on public health, it was decided to conduct experiments on Wheat and Green gram crop at the Nirma University Campus, Ahmedabad as shown in Figures 1 & 2, respectively.[8,9]

The experimental design was consisting of irrigation treatments, fertilizer treatments and replications which are shown in Tables 1, 2 and 3, respectively.

Fig. 1: Experimental Set-up for Wheat Crop

Fig. 2: Experimental Set-up for Green gram Crop

Table 1: Irrigation Treatments

Treatment	Sewage water	Ground water	Surface water
T1	100 % of In	0 % of In	0 % of In
T2	66.66 % of In	33.33 % of In	0 % of In
T3	33.33 % of In	66.66 % of In	0 % of In
T4	0 % of In	100 % of In	0 % of In
T5	66.66 % of In	0 % of In	33.33 % of In
T6	33.33 % of In	0 % of In	66.66 % of In
T7	0 % of In	0 % of In	100 % of In

In = Nos. of Irrigations

Table 2: Fertilizer Treatments

Treatment	Nitrogenous fertilizer
N1	100 % of recommended dose
N2	75 % of recommended dose
N3	50 % of recommended dose

Table 3: Replications of Experiments

Experiment No.	Crop	Replication
1	Wheat	I
2	Green gram	I
3	Wheat	II
4	Green gram	II
5	Wheat	III
6	Green gram	III

Considering the substantial presence of nitrogen in sewage effluent, experiments were designed to explore the scope of reducing dose of nitrogenous fertilizer to wheat and green gram. To assess the benefits of nitrogen-rich sewage effluent, three fertilizer treatments were considered: N1 with 100 % of the recommended dose of nitrogenous fertilizer, N2 with 75 % of the recommended dose of nitrogenous fertilizer and N3 with 50 % of the recommended dose of nitrogenous fertilizer were considered.

Two agricultural workers were assigned tasks related to the cultivation of wheat and green crops including irrigation with sewage effluent, surface water and groundwater in different blending ratios throughout all experiments.[10]

In research studies exploring health impacts on agricultural workers exposed to wastewater irrigation, water quality parameters play a crucial role.[11,12] Chemical, Physical and Microbiological Parameters of water quality help assess the potential hazards associated with exposure and establish links between water composition and observed health effects. Workers might be exposed through direct contact with contaminated water during irrigation, harvesting, or soil handling, as well as through inhalation of aerosols. By integrating water quality assessments with health surveys, studies can better quantify the risks and advocate for safer reuse of wastewater in agriculture.

The sewage effluent from the Gandhinagar Township Sewage Treatment Plant, surface water from the Narmada Main Canal and groundwater from the borewell located near the experimental site were utilised for irrigating wheat and green gram. The characteristics of these various types of water used in irrigation are presented in Table 4.[13]

Table 4: Characteristics of Irrigation Water

Particulars	Sewage Water	Ground Water	Surface Water
Colour, Hazen Unit	Light black	Colourless	Colourless
Odour	Odorous	Odourless	Odourless
Turbidity, NTU	53.70	0.3	0.6
pH	7.83	8.06	7.97
EC (mmhos/cm)	1130	1410	340
Total Hardness (as $CaCO_{3)}$ mg/l	192	232	120
TSS (mg/l)	176	98	65
TDS (mg/l)	873	1138	168
TS (mg/l)	1049	1236	233
Oil & Grease (mg/l)	2.1	BDL	BDL
BOD (5 days 20 ^{O}C) mg/l	29	NA	NA
COD (mg/l)	104	NA	NA
As (mg/l)	BDL	BDL	BDL
B (mg/l)	BDL	BDL	BDL
Ca (mg/l)	36	43.2	28
Mg (mg/l)	24.48	29.76	12
Na (mg/l)	157	208	20
CO_3 (mg/l)	19.20	24	26.4
HCO_3 (mg/l)	429.44	348.92	120.78
% Na	56.74	58.62	26.6
RSC (mg/l)	3.52	1.48	0.02
SAR	5.24	6.28	0.79
CN (mg/l)	BDL	BDL	BDL
Cl (mg/l)	120	216	20
NO_3 (mg/l)	28.09	7.99	5.09
SO_4 (mg/l)	77.6	156.2	8.58
F (mg/l)	0.93	1.06	0.48
Total Alkalinity (as $CaCO_3$) mg/l	344	307.6	128.8
Mn (mg/l)	0.12	BDL	BDL

Pesticides (mg/l)	BDL	BDL	BDL
Detergents (mg/l)	BDL	BDL	BDL
Phenolic compounds, (mg/l)	BDL	BDL	BDL
Ammonical Nitrogen, (mg/l)	08	BDL	BDL
Cu (mg/l)	0.2	BDL	BDL
Fe (mg/l)	BDL	BDL	BDL
Zn (mg/l)	0.04	BDL	BDL
Pb (mg/l)	BDL	BDL	BDL
Fecal Coliform (MPN/ml)	P	NA	NA
Total Coliform (MPN/ml)	24	NA	NA

P-Present, BDL-Below Detectable Limit, NA-Not Applicable, MPN-Most Probable Number, NTU-Nephelometric Turbidity Unit, EC-Electrical Conductivity, TSS-Total Suspended Solids, TDS-Total Dissolved Solids, TS-Total Solids, BOD-Biochemical Oxygen Demand, COD-Chemical Oxygen Demand, RSC- Residual Sodium Carbonate

Results and Discussion

The health conditions of the two agricultural workers associated with sewage water irrigation for wheat and green gram cultivation were examined by conducting various pathology tests as shown in Table 5 and 6.

Table 5: Examination of Health Conditions of Agricultural Worker-I

Test	Result	Normal Range
(I) Lead Estimation by Atomic Absorption		
Lead level	0.00 mg/dL	0-20 mg/dL
(II) Biochemical Investigations on Cobas Integra 400 (Roche)		
Total Bilirubin	0.50 mg/dL	0.00-1.30
Conjugated Bilirubin	0.10 mg/dL	0.00-0.30
Unconjugated Bilirubin	0.40 mg/dL	0.00-1.00
SGPT	17.10 U/L	0.00-40.00
(III) Differential Leucocyte Count		
Polymorphs	45 %	40-70
Lymphocytes	42 %	20-45
Eosinophils	5 %	1-6
Monocytes	8 %	2-10
Basophils	0 %	0-1.5
(IV) Platelet Count		
Platelet	355000 / cmm	150000-500000

SGPT- Serum Glutamate Pyruvate Transaminase

Table 6: Examination of Health Conditions of Agricultural Worker-II

Test	Result	Normal Range
(I) Lead Estimation by Atomic Absorption		
Lead level	0.00 mg/dL	0-20 mg/dL
(II) Biochemical Investigations on Cobas Integra 400 (Roche)		
Total Bilirubin	0.40 mg/dL	0.00-1.30

Conjugated Bilirubin	0.20 mg/dL	0.00-0.30
Unconjugated Bilirubin	0.20 mg/dL	0.00-1.00
SGPT	31.90 U/L	0.00-40.00
(III) Differential Leucocyte Count		
Polymorphs	40 %	40-70
Lymphocytes	41 %	20-45
Eosinophils	8 %	1-6
Monocytes	10 %	2-10
Basophils	1 %	0-1.5
(IV) Platelet Count		
Platelet	273000 / cmm	150000-500000

SGPT- Serum Glutamate Pyruvate Transaminase

Two workers were exposed to wastewater irrigation during three replications of wheat and three replications of green gram cultivation over a period of three consecutive years. The same two workers participated consistently throughout the entire research period. Since the study aimed to assess the long term impacts of irrigation using wastewater, health risks were evaluated only once after the full three years of research period and not at any point during the study. Consequently, the single health assessment of these two workers conducted after completing all experimental replications does not necessitate statistical analysis.

The long-term health implications for each test parameter are stated as follows.

Heavy metal (Lead) present in wastewater moves into soil and crops, potentially entering workers' systems through dermal contact or inhalation. Long-term exposure may lead to chronic health issues, including kidney damage, neurotoxicity, and cancer.

Bilirubin Total levels cause potential liver damage or systemic infections. Bilirubin Conjugated reflects liver's ability to conjugate and excrete bilirubin; dysfunction may signal liver disease or bile duct obstruction. Bilirubin Unconjugated highlights the liver's capacity to process waste products and potential hemolytic conditions.

Differential Leucocyte Counts provide critical insights into the immune response and potential health issues in agricultural workers exposed to wastewater irrigation. Polymorphs counts reflect the body's immediate immune response to infections or toxic insults. Lymphocyte counts highlight immune system status and potential long-term impacts of wastewater exposure. Eosinophil counts are crucial for detecting parasitic and allergic responses in workers exposed to untreated wastewater. Monocyte counts indicate ongoing inflammation or chronic infections that may be linked to wastewater exposure. Basophil counts provide insight into allergic or chronic immune responses triggered by environmental exposures.

Low platelets increase the risk of excessive bleeding and impaired wound healing, which can be dangerous in a work environment prone to cuts and abrasions. High platelets can manifold the risk of thrombosis (blood clots), which may lead to complications such as strokes or heart attacks, especially if workers have underlying health conditions.

Conclusion

The lead level in agricultural workers associated with sewage water irrigation for wheat and green gram crops was found to be within the normal range, as reflected through the lead estimation test by Atomic Absorption. Total bilirubin total, conjugated bilirubin, unconjugated bilirubin and S.G.P.T. values in the above workers were found to be within the normal range as per biochemical investigations on Cobas Integra 400 (Roche). Polymorphs, lymphocytes, eosinophils, monocytes and basophils values in the above workers were found to be within the normal range as noticed by test of differential Leucocyte count. Platelet value in above workers is found within normal range according to the platelet count test results. Hence, it is concluded that the application of sewage water for irrigation of wheat and green gram crops does not cause any adverse effects on the health of the concerned agricultural workers.

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Conflict of Interest

The author do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

This research involved human participants who were agricultural workers. Their involvement in the research did not result in any adverse effects on their health. This research did not involve any animal subjects or any other material that requires ethical approval.

Informed Consent Statement

As this study involved human participants who were agricultural workers, informed consent was obtained. Both agricultural workers gave their consent to participate throughout the entire research period. No adverse health implications were observed as a result of their involvement in the study.

Author Contributions

The sole author was responsible for the conceptualization, methodology, data collection, analysis, writing, and final approval of the manuscript

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