

**IMPACT ASSESSMENT OF CONTAMINATED AND TREATED
WASTEWATER ON SOIL AND CROP QUALITY USING DIFFERENT
SYSTEMS OF IRRIGATION IN THE NCR REGION**

SUMIT PAL



CENTRE FOR RURAL DEVELOPMENT & TECHNOLOGY

INDIAN INSTITUTE OF TECHNOLOGY DELHI

MAY 2018

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by

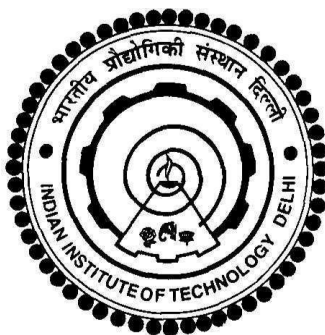
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CENTRE FOR RURAL DEVELOPMENT & TECHNOLOGY

Submitted

in fulfilment of the requirements of degree of Doctor of Philosophy

to the



INDIAN INSTITUTE OF TECHNOLOGY DELHI

MAY 2018

CERTIFICATE

This is to certify that the thesis entitled **“Impact assessment of contaminated and treated wastewater on soil and crop quality using different systems of irrigation in the NCR region”**, being submitted by **Mr. Sumit Pal** to the Indian Institute of Technology, Delhi for the award of **“Doctor of Philosophy”** is a record of bonafide research work carried out by him. He has worked under our guidance and supervision and has fulfilled the requirements for the submission of this thesis. To the best of our knowledge the results contained in this thesis have not been submitted in part or full to any other university or institute for award of any degree or diploma.

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ACKNOWLEDGEMENTS

*I express my sincere gratitude and indebtedness to my supervisors **Prof. Anushree Malik Professor**, Centre for Rural Development and Technology (CRDT), IIT Delhi and **Dr. Neelam Patel**, Principal Scientist, Water Technology Centre, ICAR-Indian Agricultural Research Institute ,Delhi, for their guidance and valuable suggestions throughout the research work and consistent encouragement, support and co-operation. Their dedication and keen interest above all their overwhelming attitude to help their students had been solely responsible for completing my work. Their timely advice, meticulous scrutiny, scholarly advice and scientific approach have helped to a very great extent to accomplish this work.*

I also express my gratitude to my SRC members- Prof. T.R. Sreekrishnan, Prof. Satyawati Sharma of CRDT, Prof. D. K. Singh, Delhi University and other faculty members of CRDT for their useful feedback, insightful suggestions and comments in research presentations from time to time. I am extremely thankful to Dr. T.B.S. Rajput, Emeritus Scientist, Mrs. K. G. Rosin, Scientist and Dr. Khajanchi Lal, Principal Scientist, Water Technology Centre, IARI, Delhi for providing help in research studies. I would also extend my sincere gratitude to Prof. Hitendra Malik, Physics Department, IIT Delhi for his word of encouragement and motivation. I would also like to acknowledge my seniors Dr. Megha Mathur, Dr. Nitin Chauhan, Dr. Prachi Kaushik and Dr. Abhishek Mishra of IIT Delhi and Dr. G.B. Rajurkar of ICAR-IARI, Delhi for their guidance in planning and execution of experiments and their valuable feedback.

A special thanks to Mr. Maneesh Namurath for providing unconditional help in bioreactor maintenance at Field. I wish to acknowledge my lab members Deepak Gola, Dr. Poonam Choudhary, Arghya Bhattacharya, Pushpendar Kumar and Dr. Priyadarshini Dey of IIT Delhi and Gaurav Singh , Mairaj Hussain, Deepak K. Dinkar , Rupin Upadhyay of ICAR-IARI, Delhi for extending their help during the period of experimentation and thesis preparation. I thankfully acknowledge the members of Metagenomics Lab and Waste Treatment Lab, Biochemical Engineering and Biotechnology for providing help and guidance in instrumentation to conduct microbial community studies. I thank Mr. Vinod Kumar and Mr. Sabal Kumar of IIT delhi and Mr. Ramshankar , Mr. Suchendar , Mr. Ramdarsh Thakur ,Mr. Saif Ahmed ,Mr. Giriraj Sharma , Mr. Rahul Kumar and Mr. Rahul Tiwari of ICAR-IARI , Delhi for their kind help and co-operation throughout my experimentation study.

I am extremely thankful to my friends Mahendra S. Rajawat , Upma , Yogendra Verma ,Sandeep Nagrajan ,Neha, Khusboo, Anurup, Nikhil, Kanchan and Jitendra for making the journey more memorable.

My parents, brother and sister's blessings, inspiration, help in adverse situations and consistent encouragement to carry out my study have been the supreme force behind my academic career in general and this dissertation in particular. Above all, I thank almighty God for bestowing good health to me throughout the course of the study.

Sumit Pal

ABSTRACT

The objective of the present study was to assess the quality of Yamuna River and drain water in terms of heavy metal contamination and other water quality parameters. The impact of application of untreated waste water and treated waste water on soil and crop quality was assessed.

With rapid industrialization and exponential population growth in developing countries, more use of clean water per capita leads to more generation of waste water. Due to lack of adequate treatment of domestic waste water including sewage, the contaminated water is released for farming in urban and peri-urban areas. Typically, such water contains excessive quantities of nutrients, however it is contaminated with pathogens and toxic chemical substances that affect both the ecosystem and the public health.

In many areas, the untreated urban waste water is used by local farmers for irrigating crops, thus introducing these pollutants to the crops mainly in peri-urban ecosystem, due to its easy availability, disposal problems and scarcity of fresh water. Continuous irrigation of agricultural land with such wastewater may cause heavy metal accumulation in the soil and plants cultivated on such land. At state level, the 15 different sampling sites were selected covering Delhi-NCR region for the heavy metals dynamics study in soil and crop where waste water is used for irrigation. The health risk assessment of crops grown using this water and consequently consumed by people was comprehensively investigated. It was concluded that the Punjabi bagh was the most polluted site followed by Nehru Vihar and Daryia Nalla. In case of soil, concentration of metal increased away from the bank of river and also with the depth. While in crops, ladyfinger, brinjal, bittergourd, ridgegourd, bottlegourd and beans showed higher values of Hazard Index.

The Metal Pollution Index value for the brinjal, pigweed, bottlegourd, armenian cucumber, ridgegourd, red spinach and bittergourd was very high as compared to other vegetables. Health risk index for Cu (II), Cr (IV), Ni (II) and Zn (II) was less than 1, but in the case of Pb (II), the value of more than 1 except rice. A field experiment was conducted from 2014 - 2017, to investigate the effects of drip and flood method of irrigation using untreated wastewater, and treated wastewater and their impact on soil and crop quality at the 12-C Research farm of Indian Agricultural Research Institute(IARI), Delhi. The selection of crops was based on those that are locally grown and consumed in Delhi-NCR. The conventional method of irrigation (flood) and micro irrigation (drip) were selected for the comparative study. A split-split plot design was used for the treatments. Treatments include, waste water irrigated and treated water irrigated plots with two method of irrigation i.e. drip and flood irrigation with different seasonal crops. The crops i.e. Potato and Spinach for the winter season, Okra and Bottlegourd were selected for comprehensive study. A bioreactor was installed at 12-C field for the purpose of treatment of waste water before irrigation. Study concludes that untreated waste water irrigation, increases the level of metals in soil profile which were increased with time. While for treated water irrigation the concentration of heavy metals were very less. In case of crops, the level of heavy metals was found more in waste water irrigated crops than the treated water irrigated crops. In flood and drip irrigation, untreated waste water with drip irrigated crops had less metal accumulation then the flood irrigated. In treated waste water irrigated crops, both flood and drip methods have far better results than untreated waste water. The drip accumulates 27.7%, 31.2%, 18.05% and 26.11% less total metal than flood in edible part of Potato, Spinach, Bottlegourd and Okra, respectively.

From statistical point of view, highly significant ($p=0.050$) interaction were obtained between metals and irrigation method applied, irrigation methods with studied year and metal with studied year. From the study, it can be concluded that wastewater cannot be used in agricultural land for long time, while treated wastewater can be used for sustainable agriculture in the long term. The health of consumers will not be affected with metal contamination if treated waste water is used for irrigation.

सार

वर्तमान अध्ययन का उद्देश्य भारी धातु प्रदूषण एवं अन्य जल गुणवत्ता मानकों के संदर्भ में यमुना नदी के पानी की गुणवत्ता और उसमें गिरने वाले प्रमुख नालों के आकलन करने के साथ-साथ अनुपचारित एवं उपचारित अपशिष्ट जल का सिंचाई में प्रयोग और उनका मिट्टी और फसल की गुणवत्ता पर प्रभाव का आकलन करना था।

विकासशील देशों में तेजी से औद्योगिकीकरण और घातीय जनसंख्या वृद्धि के कारण, स्वच्छ जल का अधिक उपयोग भी अपशिष्ट जल के अधिक बनने का कारण बनता है। मलसहित घरेलू अपशिष्ट जल के पर्याप्त उपचार की कमी के कारण शहरी और परिनगरीय क्षेत्रों में खेती के लिए प्रदूषित पानी का उपयोग किया जाता है। आम तौर पर, इस तरह के पानी में पोषक तत्वों की अत्यधिक मात्रा होती है, हालांकि यह रोगजनकों और जहरीले रासायनिक पदार्थों से दूषित होता है जो पारिस्थितिक तंत्र और सार्वजनिक स्वास्थ्य, दोनों को प्रभावित करते हैं।

कई क्षेत्रों में, अनुपचारित शहरी अपशिष्ट जल का उपयोग स्थानीय किसानों द्वारा फसलों की सिंचाई करने के लिए किया जाता है, इस प्रकार ये प्रदूषक परिनगरीय पारिस्थितिक तंत्र में आ जाते हैं। इनकी आसान उपलब्धता, उपचार की समस्या और स्वच्छ पानी की कमी के कारण, किसान इस दूषित जल को सिंचाई के लिए उपयोग करते हैं। इस तरह के अपशिष्ट जल के लगातार उपयोग से मिट्टी एवं पौधों में भारी धातु का संचय होता है।

राज्य स्तर पर, मिट्टी और फसल में भारी धातुओं की मात्रा का अध्ययन करने के लिए दिल्ली और आस पास के पंद्रह विभिन्न स्थलों का चयन किया गया, जहां सिंचाई के लिए अनुपचारित जल का उपयोग किया जाता है। इस पानी का उपयोग करके उगाई गई फसलों से स्वास्थ्य पर पड़ने वाले जोखिमों का मूल्यांकन किया गया, जो की लोगों द्वारा सेवन की जाती रही हैं और तदुपरान्त इससे पड़ने वाले परिणाम की व्यापक रूप से जांच की गई। इस अध्ययन से ये निष्कर्ष निकाला गया कि पंजाबी बाग सबसे प्रदूषित स्थल था जिसके बाद नेहरू विहार और दरयाई नाला थे। मिट्टी के मामले में, भारी धातु की मात्रा नदी के किनारे से दूर जाने पर और साथ ही खेत की गहराई में बढ़ी मिली। फसलों में, भिन्डी , बैंगन, करेला , तौरी, लोकी और फली में खतरा सूचकांक की मात्रा एक से अधिक पाई गयी । इसके साथ ही, बैंगन , चौलाई, लोकी , आर्मेनियाई ककड़ी, तौरी , लाल पालक और करेला के लिए धातु प्रदूषण सूचकांक की मात्रा अन्य अध्ययनरत सब्जियों की तुलना में बहुत अधिक थी। तांबा (), क्रोमियम (), निकल () और जस्ता () के लिए स्वास्थ्य जोखिम सूचकांक एक से कम था, लेकिन सीसा () चावल को छोड़कर बाकी में एक से अधिक था । वर्ष 2014 से 2017 तक, एक प्रयोगात्मक खेती प्रयोग किया गया, यह प्रयोग भारतीय कृषि अनुसंधान संस्थान, दिल्ली के 12-सी अनुसंधान फार्म में किया गया, जिसमे अनुपचारित एवं उपचारित अपशिष्ट जल का उपयोग प्रवाहित विधि एवं टपक सिंचाई के द्वारा मिट्टी एवं फसलों की गुणवत्ता पर उनके प्रभाव की जांच करने के लिए हुआ ।

दिल्ली और आस पास के इलाकों में स्थानीय रूप से उगाई और इस्तेमाल में लायी जाने वाली फसलों का चयन प्रयोग हेतु किया गया । प्रायोगिक खेती को दो भागो में बांटा गया जिसमे एक में प्रवाहित प्रणाली और दुसरे में टपक प्रणाली से सिंचाई की गयी। प्रयोगात्मक खेत को विभाजन -विभाजित भूखंड रूपरेखा में बांटा गया था । इस प्रयोग में मौसमी फसलों को टपक एवं प्रवाहित सिंचाई पद्धति द्वारा उपचारित एवं अनुपचारित अपशिष्ट जल से सिंचित किया गया । रबी फसलों में आलू और पालक एवं ज़ायद फसलों में भिन्डी और लोकी का चयन किया गया । अपशिष्ट जल के उपचार हेतु प्रायोगिक खेत में एक बायोरेक्टर स्थापित किया गया । अध्ययन के उपरांत ये निष्कर्ष निकला की जिस फसल की सिंचाई अनुपचारित जल से की गयी उसमे निर्धारित मानकों से अधिक भारी धातु की सांद्रता मिली वहीं उपचारित जल वाली फसलों में भारी धातु की सांद्रता मानकों से कम प्राप्त हुई इसके साथ ही टपक सिंचाई प्रणाली से अनुपचारित जल द्वारा सिंचित फसलों में धातु की मात्रा प्रवाहित प्रणाली से सिंचित फसलों से तुलना में कम प्राप्त हुई । उपचारित अपशिष्ट जल से सिंचित फसलों में प्रवाहित एवं टपक विधि दोनों में ही अनुपचारित जल से कहीं बेहतर परिणाम हैं । टपक, क्रमशः आलू, पालक, लोकी और भिन्डी के खाद्य हिस्से में प्रवाहित की तुलना में 27.7%, 31.2%, 18.05% और 26.11% कम धातु का संग्रह प्राप्त हुआ सांख्यिकीय दृष्टि से, (पी = 0.050) धातुओं और सिंचाई विधि के बीच अध्ययन में पाया गया है की ,सिंचाई पद्धतियों में

प्रत्येक वर्ष में धातु के सांद्रता में सार्थकता पाई गयी। अध्यन से ये निष्कर्ष निकला की अनुपचारित अपशिष्ट जल का उपयोग सिंचाई में लम्बे समय तक उपयुक्त नहीं है जबकि उपचारित अपशिष्ट जल का उपयोग लम्बे समय तक किया जा सकता है। उपचारित अपशिष्ट जल से सिंचाई करने पर उपभोक्ताओं का स्वास्थ्य, धातु प्रदूषण से प्रभावित नहीं होगा।

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