

*Dr. Deep Chakraborty & Dr. B. Roy Chowdhury* editors

# Environmental Challenges and Management Issues on Public Health





*Dr. Deep Chakraborty is an accomplished environmental and public health professional with an academic background in M.Sc. and Ph.D. in Environmental Science, complemented by an ICMR Postdoctoral Fellowship in Public Health and a Postgraduate Diploma in Environmental Law and Policy (PGDELP). He is currently serving as Assistant Professor in the Department of Environmental Health Engineering at the Sri Ramachandra Faculty of Public Health, Sri Ramachandra Institute of Higher Education and Research (Deemed to be University), Chennai. Dr. Chakraborty is actively associated with nationally and internationally recognized research ecosystems, including the WHO Collaborating Centre for Research and Training in Occupational and Environmental Health and the ICMR Centre for Advanced Research on Air Quality, Climate and Health. His academic and research interests focus on environmental exposures, air quality, climate change, and their implications for occupational and public health.*



*Dr. Biswajit Roy Chowdhury, faculty member in the Department of Geography of Vidyasagar College (affiliated to University of Calcutta), Kolkata and the founder Chairman of SAIARD Research Group, has obtained his Ph.D. & M.Sc. in Geography from Calcutta University with a specialization in Urban and Transport Geography. He is also awarded Honorary Doctorate from UN Rescue Services, Nigeria. Along with the teaching he has engaged in number of academic and administrative activities and acted as a Steering Committee member in G-20 India. He has significantly contributed in the field of urban and river studies, has been published several research papers in different national and international journals and he wrote 11 books, out of which 7 books were published by the School Education Dept., Govt. of West Bengal. He was awarded by the Junior Scientist of the Year 2017 Award & Young Innovator Award 2018. and has obtained life memberships of some reputed organizations like INCA, ISCA, IIPA, IMS etc.*



**SAIARD**

South Asian Institute for Advanced  
Research & Development (SAIARD)

A Global Policy Advocacy Research Think Tank



978-81-954965-8-7

# **Environmental Challenges and Management Issues on Public Health**

*Edited by*

**Dr. Deep Chakraborty  
&  
Dr. B. Roy Chowdhury**

*Published by*



First published in 2026

By

SAIARD

87/210, Raja S.C.Mallik Road, Kolkata- 700047

Email:saiardkolkata@gmail.com

[www.saiard.co.in](http://www.saiard.co.in)

Disclaimer:

The findings, views, opinions expressed in this book are solely those of the authours and do not necessarily reflect the views of the publisher

© SAIARD

ALL RIGHTS RESERVED No part of this book shall be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright holder(s) and and/or the publishers.

## **Environmental Challenges and Management Issues on Public Health**

*Edited by:* Dr. Deep Chakraborty & B. Roy Chowdhury

ISBN: 978-81-954965-8-7

Price: 600/- (Six hundred only)

Printed By: SAIARD

## PREFACE

The book *Environmental Challenges and Management Issues on Public Health*, published by the South Asian Institute for Advanced Research and Development (SAIARD), presents an interdisciplinary examination of the growing interconnections between environmental change and public health risks. It brings together scholarly contributions that address how climate change, industrial activities, and rapid urbanization are reshaping exposure pathways and health outcomes, particularly in vulnerable regions. The volume emphasizes the need for integrated environmental management and public health planning to respond effectively to emerging and persistent challenges.

A significant part of the book focuses on environmental contaminants, technological interventions, and occupational exposures that directly influence human health. Chapters on microbial biofiltration for indoor air quality improvement, nanoparticles in public health, and the effects of occupational exposure highlight both innovative solutions and associated risks. Further, the volume critically explores climate change-driven exposure to organochlorine pesticides, endocrine-disrupting chemicals, and emerging persistent organic pollutants in water systems, underscoring their long-term implications for population health and regulatory frameworks.

The book also extends its scope to resilience-building and practical public health interventions. Assessments of climate-induced coastal erosion and community resilience in West Africa provide important socio-environmental perspectives, while the discussion on domestic wastewater disinfection through Solar Water Disinfection (SODIS) demonstrates cost-effective and sustainable approaches to protecting public health. Overall, the volume offers evidence-based insights for researchers, policymakers, and practitioners, contributing to informed decision-making and sustainable strategies for addressing public health challenges in a changing environmental context.

# CONTENTS

1. **Domestic Wastewater Disinfection by SODIS: Protecting Public Health** *By Ankita Bhattacharjee, Susmita Lahiri, Jatindranath Bhakta*
2. **Assessing the Resilience of West African Coastal Communities to Climate-Induced Erosion** *By Adepeju Nusirat BABALOLA*
3. **Emerging persistent organic pollutants (POPs) in water due to climate change and its public health challenges** *By Chandrima Goswami*
4. **Climate change and exposure to endocrine-disrupting chemicals (EDCs) threats to public health** *By GnaanaSri K and Deep Chakraborty*
5. **Climate change and air pollution related Organochlorine Pesticides (OCPs) exposure and challenges to public health** *By Pradip Mitra and Deep Chakraborty*
6. **Effects of Occupational Exposure on Human Health** *By Chittaranjan Das*
7. **Nanoparticles in Public Health: Applications, Risks, and Future Directions** *By Sonal Singh, Gauri Kukreja, Mansi Sharma, Maahi Rastogi, Kuldeep Dwivedi*
8. **Microbial Biofiltration Systems for Indoor Air Quality Improvement for the Betterment of Public Health from volatile and PAH compounds** *By Manglam Soni, Shivam Kumar, Himanshu Bhojwani, Kuldeep Dwivedi*

# Domestic Wastewater Disinfection by SODIS: Protecting Public Health

Ankita Bhattacharjee<sup>1</sup>, Susmita Lahiri<sup>2</sup>, Jatindranath Bhakta<sup>2</sup>

<sup>1</sup>Department of Environmental Studies, Sree Chaitanya Mahavidyalaya, Prafullanagar, Habra- 743268, West Bengal

<sup>2</sup>Department of Ecological Studies, University of Kalyani, Kalyani-741235, West Bengal, India

## Abstract

Considering the increasing demand for water conservation, safe use of water and other related problems of this life saving matrix with its future risk, the present study has used modified SODIS techniques which proved to be quite effective in disinfection of municipal wastewater. Considering the vehement increase of pollution and contamination level of water as a continuous process, the present study has sought to enhance the efficiency of the general SODIS disinfection method by using the box type solar cooker which collect and reflects solar energy inside that resulted in raising the temperature to as high as 115°C inside recording a 100% destruction of pathogenic bacteria as well as heterotrophic bacteria. This treated wastewater is further used for seed germination (*Triticum aestivum*) in Petri plate to see its impact so that this technique can be further used in large scale considering its harmful impact on human health.

**Keywords:** SODIS, germination, pathogenic, bacteria, human health

## 1. Introduction

Industrial based lifestyle by world's ever-increasing population led to severe impact on the environment causing qualitative and quantitative threat to water (Asamudo et al., 2005; WMD, 2006). The water consumption scenario in India has become quite alarming in recent years (Rahecha, 2020). In view of this increasing quantitative water calamity there is an urgent need to conserve water to save this world from environmental degradation (UNEP, 2002) which have the high chance of continuing in future.

Water is also threatened qualitatively by the huge global production of domestic sewage and industrial waste which are the integral part of any modern city of the world. Treated or partly treated or untreated wastewater is disposed into natural drains connecting rivers or lakes or on land for irrigation/ fodder cultivation purpose or into the sea by the municipalities, it causes unacceptable deterioration of water quality either by severe contamination or eutrophication and serves as a major source of water pollution in India (Bincy et al., 2015).

Domestic sewage is mainly a cocktail of organic and inorganic substances in dissolved and suspended form along with heavy metals and microorganisms (Bhowmick et al., 2000; Henze et al., 2001, Zhang et al., 2014) that causes threat to public health (Zhou et al., 2007; Varela et al., 2013) by infecting new host through ingestion (Toze, 1999). Some of the reported microbial pathogens present in wastewater are: Poliovirus, Enterovirus, Echovirus, Adenovirus, Reovirus, Rotavirus, Hepatitis A virus, *Vibrio cholera*, *Salmonella typhi*, *Escherichia Coli*, *Campylobacter jejuni*, *Shigella dysinterae*, *Yersinia enterocolitica*, *Giardia intestinalis*, *Cryptosporidium parvum*, *Entamoeba histolytica*, *Ascaris lumbricoides*, *Ancylostoma spp.*,

*Trichuris trichiura*, *Strongiloi dessterocoralis* (Dungeni et al., 2010; Coronel-Olivares et al., 2010).

Reuse of treated sewage or wastewater is of great global attention as it minimises water shortage issue (Mishra et al., 2023). In order to meet the Sustainable Development Goals (SDGs) by 2030 (United Nations, 2016) the United Nations (UN) has pushed for the implementation of wastewater reuse all over the world. Several studies have examined the impacts of reused treated wastewater on land, agriculture, aquatic bodies, economic viability, and public health problems. According to Ibekwe et al. (2018) soil physicochemical and microbiological qualities that affect crop yield and public health should be considered before recycling wastewater for agricultural activity. Various disinfection techniques are available to disinfect wastewater before its reuse but most of them were quite expensive that are not pocket friendly for all the farmers of our country. For this reason SODIS method has been chosen for wastewater disinfection.

Therefore, the present study has been aimed to utilize the potential of modified SODIS technique for the assessment of (i) the wastewater disinfection efficiency (ii) the optimum time duration required for wastewater disinfection from pathogenic microbial contamination (iii) application potential of the disinfected wastewater for the germination of wheat seed after all public health benefits.

## **2. Materials and Methods**

### **2.1. Disinfection Experiment**

#### **2.1.1. Experimental**

The experiment was conducted using solar disinfection system (SDS, Geetanjali Solar Enterprise) purchased as described below in Fig.1.1.

Iv	Insulation materials	: Glass wool
V	04Nos.Aluminium container covered with toughened glass	: 4 mm
Vi	Inbuilt analog	: Temperature meter
	Approx. weight	: 4 kg

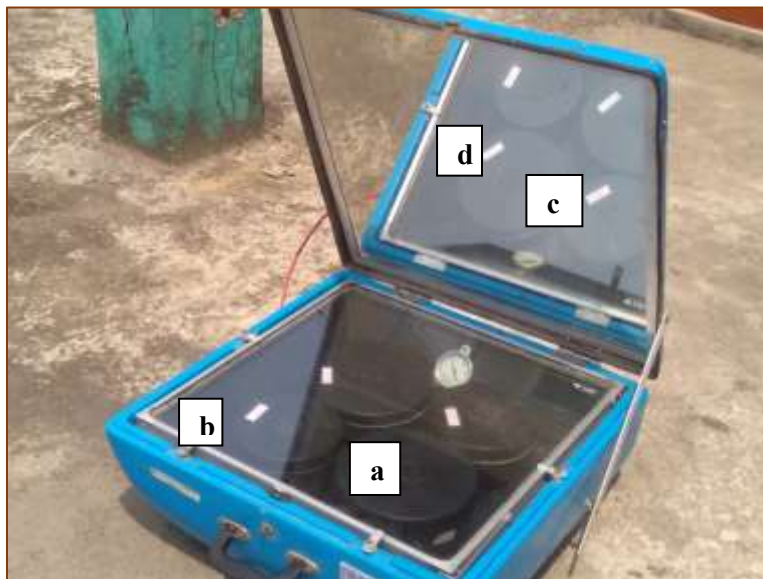


Fig.1.1. Box type solar cooker (a, b, c, d of the different parts in SDS)

### 2.1.3. Culture media and glass wares

Cultured media used in this study was chromocult agar (MERCK). The following are composition of the chromocult agar media was mentioned in general methodology section.

### 2.1.4. Temperature and light intensity measurement

Temperature (°C) inside the solar cooker and light intensity were measured at regular intervals of 0, 1, 2, 3 and 4 h periods using

thermometer and LUX meter respectively throughout the experimentation.

### **2.1.5. Microbial examination**

The samples were collected from the experimental pots. All samples were at first sequentially diluted with sterile buffered water using three dilution factors ( $10^1 - 10^3$ ) based on previous analyses of similar samples. Then the aliquots were examined for microorganisms using membrane filtration methods (APHA, 2012). The cells recovered on a membrane filter were directly cultured on chromocult agar medium to determine total coliforms and *E. coli*. The plates were incubated at 37°C for 24hour. Each analytical batch included blanks and positive controls. After incubation, the plates were manually enumerated. All results were volume normalized to give concentrations in colony forming units (CFU) per 100 mL.

After the experiment, the treated wastewater was used for the germination of wheat seed (*Triticum aestivum*).

### **2.1.6. Seed Germination Experiment**

Seed germination study was performed using the domestic wastewater collected from modified SODIS disinfection experiment at 0, 1, 2, 3 and 4 h periods to assess whether the treated/disinfected water has the seed germination ability without pathogenic infection. Three hundred seeds of wheat (*Triticum aestivum*) were surface-sterilized with 2% sodium hypochlorite solution for 1 min and washed 5 times in single distilled water followed by air-drying (Miche and Balandreau, 2001). All dried sterilized seeds were randomly divided into five groups with three replicate ( $20 \times 3 \times 5 = 300$ ). Five groups were treated by 5 mL wastewater collected at 0, 1,

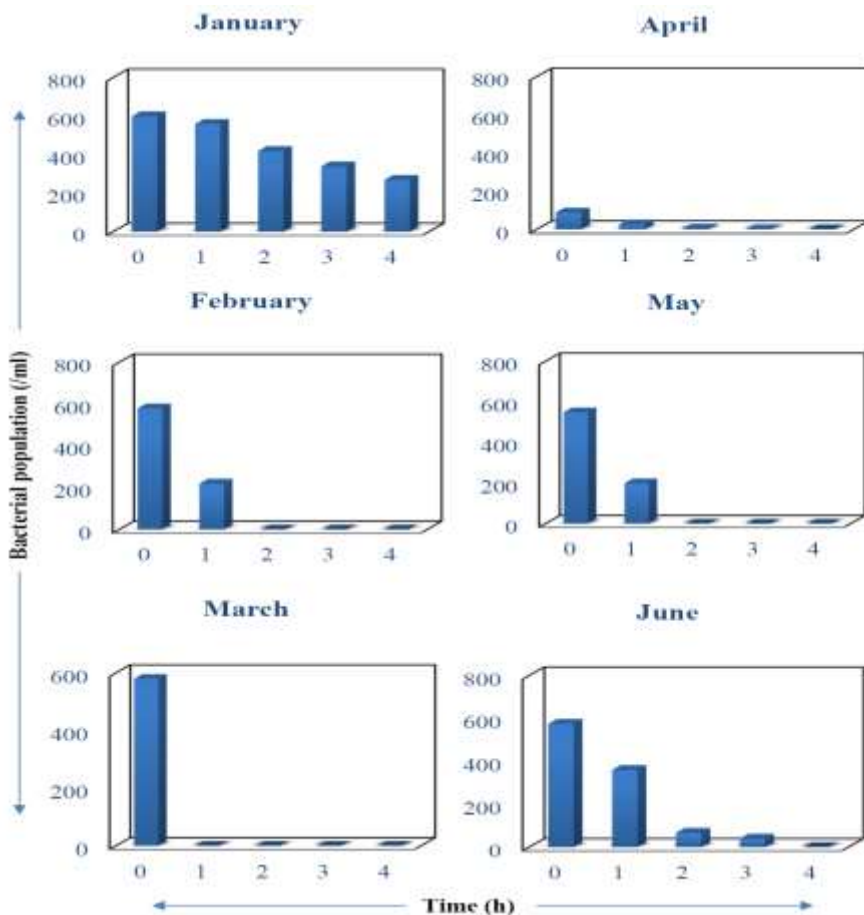
4h, whereas, light intensity keeps on increasing with time resulting in 99% reduction of bacterial population.

### **3.1.2.2. *Escherichia Coli***

The number of *E. coli* bacteria ranged from  $0.6 - 0.5 \times 10^3/\text{mL}$  in all months (Fig.1.4). The bacterial number was decreased with increasing time and temperature in all the months studied (Fig.1.4). The decreasing rates of coliform bacteria were 55%, 100%, 100%, 100%, 100% and 100% in January, February, March, April, May and June, respectively at 4 hour period of study. At 1 h period, the decrease in *E. coli* population was maximum (100%) in March and minimum in January (55%) months.

In the month of January, 55% reduction in bacterial population was observed which is related with temperature ( $r=-0.74695$ ) as well as with time ( $r=0.801$ ). Similarly, in the month of February 100% reduction was observed within 4 h period, although very little fluctuation in temperature was observed between January and February. The temperature ( $60^\circ\text{C}$ ) and light intensity ( $4.2 \mu\text{mol/s/m}^2$ ) was quite high at initiation time of experiment in the month of March, which further increased as the time progressed and reached to  $110^\circ\text{C}$  and  $4.45 \mu\text{mol/s/m}^2$  within 4 h resulting in 100% destruction of coliform (*E. coli*). In the month of April and May, a similar trend was observed in *E.coli* population (100% reduction). In the month of June 100% reduction in *E.coli* was observed within 3 h exposure of wastewater to solar radiation when light intensity and temperature reached to  $4.58 \mu\text{mol/s/m}^2$  and  $100^\circ\text{C}$  within 4 h. The bacterial inactivation rate in wastewater sample is proportional to the intensity of sunlight and atmospheric temperature (Acra et al., 1990). Above figure suggest the effectiveness of solar radiation is directly proportional with reduction in microbial load. In this month

temperature ranges between 45-100°C which is enough for destroying bacteria as temperature above 45°C completely inactivates the bacteria present in water (Dunlop et al., 2011). The rate of bacterial inactivation for sample temperatures ranging from 12 to 40°C, when the water temperature was increased to 50°C, the same fraction of the initial population of *E. coli* was inactivated (Caslake et al., 2004).



**Fig.1.4.** The change of *E. Coli* population with time, temperature and light intensity in different months (from month of January to June)

### 3.1.2.3. *Salmonella*

The population of *Salmonella* varied from  $0.6 - 0.5 \times 10^3/\text{mL}$  in all months (Fig.1.5). The bacterial population was decreased with increasing time and temperature in all the months studied (Fig.1.5). The decreasing rates of *Salmonella* population were 66%, 100%, 70%, 100%, 100% and 100% in January, February, March, April, May and June, respectively at 4 h period of study. The *Salmonella* was not found in February, March, April, May and June at 4 h periods of experimentations, respectively.

In the month of January the initial temperature and light intensity were  $45^\circ\text{C}$  and  $0.84 \mu\text{mol/s/m}^2$  which increased to  $100^\circ\text{C}$  and  $3.44 \mu\text{mol/s/m}^2$  within 3 h period of the experiment, respectively that reduced 66.7% *Salmonella*. A sharp temperature increment in the month of February resulted in 100% killing of bacterial population. In the month of March, April and May, the initial temperature inside the box type solar cooker was increased from 60 to  $110^\circ\text{C}$ , 65 to  $70^\circ\text{C}$  and 110 to  $115^\circ\text{C}$ , respectively within 4h which is resulted in 100% destruction of bacteria. Likewise, in the month of June, the initial temperature and light intensity were increased from  $45^\circ\text{C}$  and  $3.13 \mu\text{mol/s/m}^2$  to  $80^\circ\text{C}$  and  $4.3 \mu\text{mol/s/m}^2$  results, respectively. Due to lower temperature, the reduction of *Salmonella* population (88%) was lower compared to other months within 4 hours period of experimentation. Sunlight destroys biomolecules and UV-A (wavelength of 320–400 nm) is absorbed by DNA and reactive oxygen species (ROs) are produced by solar radiation in water or wastewater. UV-A and UV-B from sunlight and the reactive molecules kill microorganisms, such as *Pseudomonas aeruginosa*, *Escherichia coli*, *Salmonella*, and *Shigella Flexneri* (Giannakis et al., 2015; Lawrie et al., 2015).

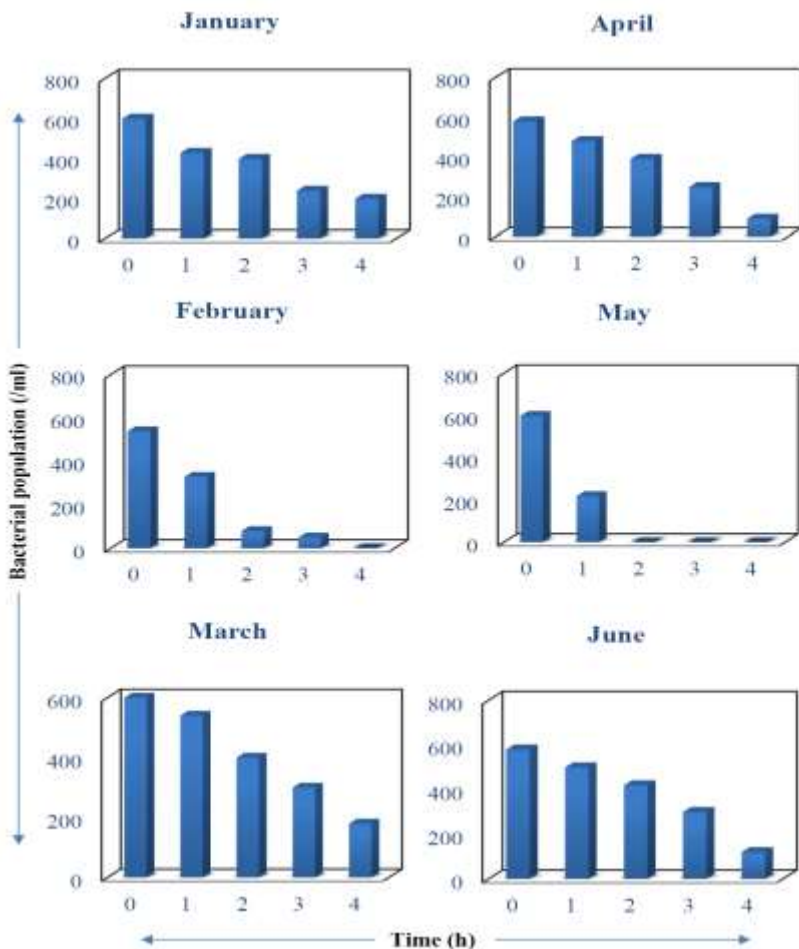
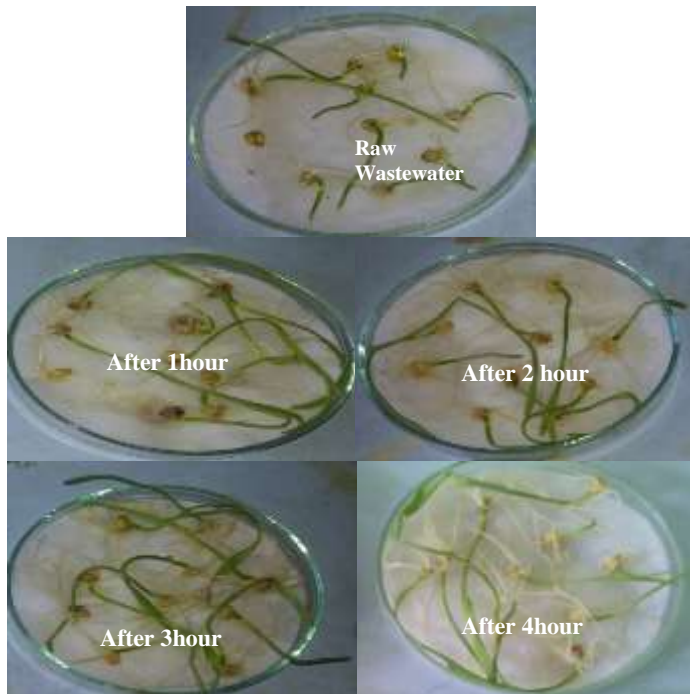


Fig.1.5. Graphical representation of *Salmonella* population in various months

### 3.1.2.4. *Enterobacteriaceae* group

The *Enterobacteriaceae* bacterial population varied from  $0.6 - 0.5 \times 10^3/\text{mL}$  in all months (Fig.1.6). The bacterial population was



**Fig.1.8. Seed germination using raw and disinfected wastewater**

From the above result it observed that germination occurred in all the treatments but the treatment with 4 h disinfected water shows the maximum growth compared to other treatments were higher in the treated water compared to the plants grown in untreated water (control).

Higher level of tested seed germination parameters and bacterial load reduction in the treatments with 4h disinfected wastewater than that in raw wastewater may be due to the fungal growth in seeds treated with raw wastewater containing high load of pathogens. Moreover production of various enzymes (Shukla and Pandey, 1991), high salinity induced physiological stress (Rao and Nanda Kumar, 1983) or due to excess quantities of micronutrients, heavy metals and

toxic chemicals (Indra and Sivaji, 2006) in raw wastewater showed adverse effect on germinated seeds. A positive correlation between bacterial load reduction with the percentage of seed germination and vigour index in disinfected wastewater treatment of 4 hour exposure indicated that decrease in bacterial load increases the rate of germination (Fig.1.9a, b, c, d) and vigour index (Fig.1.10 a1, b1, c1, d1)

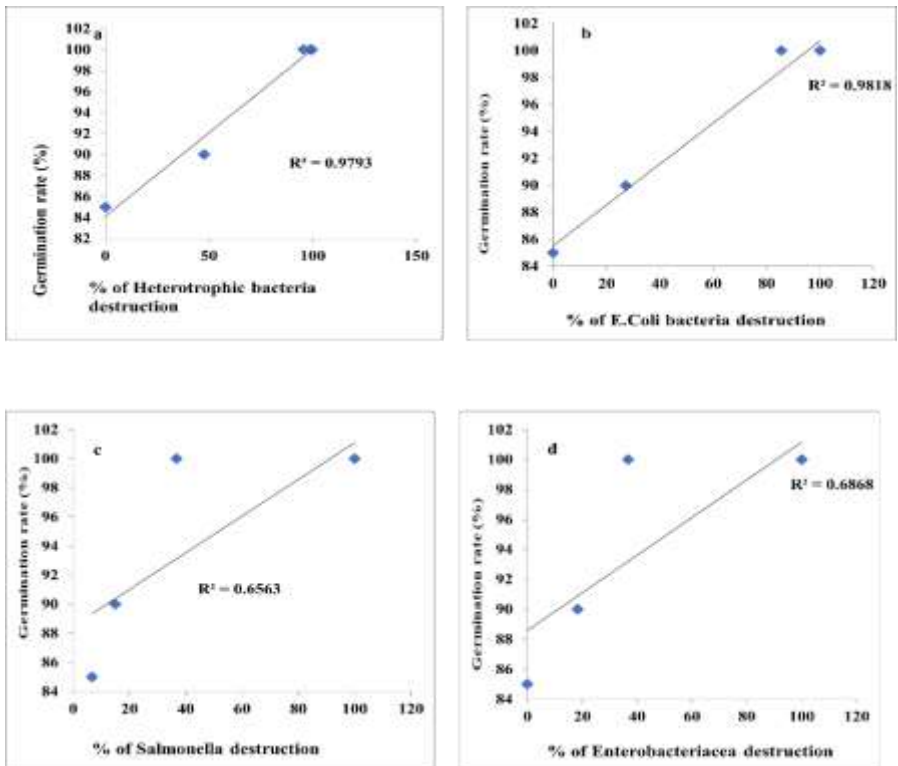


Fig.1.9. Relationship between seed germination rate and reduction of bacterial load of a) Heterotrophic bacteria, (b) *E. Coli*, (c) *Salmonella sp.*, (d) Enterobacteriaceae.  $R^2$  = goodness of fit.

to dioxins produced during burning. Much greater distances can be covered by small particles before they escape the emission source. Dioxins exhibit considerable lipophilicity and hydrophobicity; their solubility in organic solvents escalates with the concentration of chlorine. Since they are insoluble in water, the majority of them adhere firmly to any substance that contains a lot of organic matter in an aquatic environment. This is especially true of microscopic plants and animals called plankton, which are consumed by larger creatures. They move around and gather at every stage of the food chain in this manner. We refer to this process as biomagnification (**Michalowicz et al., 2010**).

Anthropogenic factors are the primary cause of dioxin and dioxin-like product production. Although there is evidence of formation in the natural world, human interaction—particularly activities connected to combustion—is the primary source of energy. The synthesis of PCDD/Fs is fueled by high-temperature interactions between chlorine and organic molecules. Therefore, since chlorine and volatile organic compounds are inevitable byproducts of the feed materials used in these processes, activities like waste incineration, metal smelting, forest fires, and diesel fuel combustion are ideal conditions for the formation of the various dioxin-like congeners (**Dopico et al., 2015**).

### **1.2.4 Perchlorate its different sources and uses**

Since the late 1990s, when improved analytical methodology allowed for a reduction in the detection limit from 400 µg/L to around 1 µg/L, perchlorate (ClO<sub>4</sub><sup>-</sup>) has become an increasingly visible hazard. Perchlorate is a synthetic and naturally occurring chemical. Perchlorate is a synthetic and naturally occurring chemical. Perchlorate investigations and cleanup will be aided by knowledge of the sources of perchlorate and its range of applications. Many sites

where perchlorate pollution is known to occur have previously been identified, but as new geographic areas are examined and more information becomes accessible, it is likely that more sites will be found. As of right now, it seems that the majority of naturally occurring perchlorate sources are restricted to dry regions. Except for the comparatively high natural perchlorate concentrations observed in Chilean caliche (precipitated salts in soil from evaporated wetting fronts) and some potash ores, these deposits are typically modest in concentration. On the other hand, compared to most natural sources, artificial sources of perchlorate can be many times more concentrated. There is continuing effort to distinguish between the two categories in contexts where both exist. High concentrations of perchlorate contamination (thousands of parts per billion or higher) have been found at sites related to the production, testing, or disposal of solid rocket propellant, the production of perchlorate compounds, and industrial manufacturing processes involving the use of perchlorate compounds as reagents.

Since perchlorate is a component of or used in many common products, such as airbag initiators for automobiles, its industrial uses are highly diverse. Additionally, laboratories utilize perchlorate's potent oxidizing powers as well as other unique qualities. For example, certain industrial operations, including the processing of rare earth element ores, call for the usage of perchloric acid. Perchlorate may be present in certain detergents. As an illustration, consider detergent-based cleaning solutions for laboratory glassware like NeuTrad, Alconox, Alcotabs, and Liquinox. Certain items (like fertilizers) that are used to increase agricultural productivity contain some naturally occurring perchlorate. In the medical field, potassium perchlorate is used to treat thyroid diseases by suppressing the overproduction of hormones caused by an overactive thyroid gland.

32. Spigno, G., Pagella, C., Daria Fumi, M., Molteni, R., & Marco De Faveri, D. (2003). VOCs removal from waste gases: Gas-phase bioreactor for the abatement of hexane by *Aspergillus niger*. *Chemical Engineering Science*, 58(3–6), 739–746. [https://doi.org/10.1016/s0009-2509\(02\)00603-6](https://doi.org/10.1016/s0009-2509(02)00603-6)
33. Stocka N, Butarewicz A, Stocki M, Borowik P, Oszako T. Biological Pollution of Indoor Air, Its Assessment and Control Methods. *Encyclopedia*. 2024; 4(3):1217-1235. <https://doi.org/10.3390/encyclopedia4030079>
34. Stocka, N., Butarewicz, A., Stocki, M., Borowik, P., & Oszako, T. (2024). Biological pollution of indoor air, its assessment and control methods. *Encyclopedia*, 4(3), 1217–1235. <https://doi.org/10.3390/encyclopedia4030079>.
35. Tekerlekopoulou, A. G., Pavlou, S., & Vayenas, D. V. (2013). Removal of ammonium, iron and manganese from potable water in biofiltration units: A review. *Journal of Chemical Technology & Biotechnology*, 88(5), 751–773. <https://doi.org/10.1002/jctb.4031>
36. Tosepu, R., Yulisti, S., Latoso, R., Ice, & Harleni. (2023). The management of wastewater treatment plants at Bhayangkara Hospital Kendari in 2022. *KnE Social Sciences*. <https://doi.org/10.18502/kss.v8i9.13361>.
37. Vergara-Fernández, A., Scott, F., & Moreno-Casas, P. (2020). Biofiltration of volatile organic compounds and polycyclic aromatic hydrocarbons. In *From Biofiltration to Promising Options in Gaseous Fluxes Biotreatment* (pp. 129–151). Elsevier. <http://dx.doi.org/10.1016/b978-0-12-819064-7.00007-8>
38. World Health Organization, 2016. Ambient Air Pollution: a Global Assessment of Exposure and Burden of Disease. World Health Organization.

39. Wu, Z., Liu, X., Lv, C., Gu, C., & Li, Y. (2021). Emergency evaluation of human health losses for water environmental pollution. *Water Policy*, 23(3), 801–818. <https://doi.org/10.2166/wp.2021.177>
40. Yadav, D., Rangabhashiyam, S., Verma, P., Singh, P., Devi, P., Kumar, P., Hussain, C. M., Gaurav, G. K., & Kumar, K. S. (2021). Environmental and health impacts of contaminants of emerging concerns: Recent treatment challenges and approaches. *Chemosphere*, 272, 129492. <https://doi.org/10.1016/j.chemosphere.2020.129492>
41. Yadav, D., Rangabhashiyam, S., Verma, P., Singh, P., Devi, P., Kumar, P., Hussain, C. M., Gaurav, G. K., & Kumar, K. S. (2021). Environmental and health impacts of contaminants of emerging concerns: Recent treatment challenges and approaches. *Chemosphere*, 272, 129492. <https://doi.org/10.1016/j.chemosphere.2020.129492>