EPRA International Journal of Socio-Economic and Environmental Outlook (SEEO) ISSN: 2348-4101
Volume: 10 | Issue: 6 | June 2023 | SJIF Impact Factor (2023): 8.153 | Journal DOI: 10.36713/epra0314 | Peer-Reviewed Journal

AN EMPIRICAL ANALYSIS ON NEXUS BETWEEN POPULATION GROWTH AND WASTEWATER GENERATION IN INDIA

S. Bhuvanesvari[1], Dr. R. Manikandan[2]
[1]*Ph.D. Research Scholar, Department of Economics, Bharathiar University, Coimbatore.*
[2]*Assistant Professor, Department of Economics, Bharathiar University, Coimbatore.*

ABSTRACT
Wastewater management is one of the biggest challenges for India. India having high population growth along with socio-economic development, rapid urbanization, and industrialization creates more pressure on freshwater resources for industrial activities, and human consumption, subsequently, the huge amount of wastewater generated. Wastewater is the biggest evil for freshwater resources and degrades the environmental quality. This situation is immensely rising the health cost to society. Therefore, this paper seeks to examine the relationship between population growth and wastewater generation in India. This research paper is based on secondary data, gathered from Central Pollution Control Board, World Bank, *and* ENVIS Report. *The correlation and linear regression tools were applied for data analysis. The correlation is positive and linear regression results show that the R^2 value is 0.977, the population growth of India and wastewater generation was statistically significant at 0.01 level. This research paper suggests to Government should effectively implement the wastewater treatment plants in major cities and make awareness among the people to reuse and recycle wastewater.*
KEYWORDS: *Population, Consumption, Wastewater, Health cost, Recycle.*

1.INTRODUCTION

India is one of the most highly populated countries in the world. The rapid population growth was increasing the basic need of human life, in that water is one of the essential requirements. Hence, the water demand for consumption activities was tremendously increased. All human activities are consumed huge quantity of fresh water after consumption, discharging more wastewater around 72,368 million liters per day and every year wastewater generation was vastly increased and only 20,236 MLD of wastewater is treated and then remains untreated. According to *the 2011 Census and the Ministry of urban development reported that in India* 80 percent of surface water is polluted due to domestic sewage. *The Central Pollution Control Board* report says that untreated sewerage is the foremost cause of 75 – 80 percent of water pollution in India. The high population growth, urban lifestyle, economic development, urbanization, changes in the water consumption pattern of households, anthropogenic activities, and lack of infrastructure development are the main reasons for the huge amount of wastewater generation in India. It creates more health issues for society in the form of waterborne diseases and water-related diseases. According to *UNICEF and FAO report on Water in Aid: Situation and Prospects* stated that water contamination is the main reason for waterborne diseases in India annually 37.7 million people are affected by waterborne diseases and diarrhoea kills 1.5 million children. The world bank estimates the health cost related to water, sanitation, and hygiene condition alone ***Rs. 470 to 610 billion per year.*** The United Nation Sustainable Development Goal 6, under that target 6.3 stated that by 2030 improve water quality, wastewater treatment, and safe reuse. But, in India every year population growth was increase, and wastewater generation also immensely increases. In India, the availability of wastewater treatment capacity creates a gap between the actual wastewater generated and treated. The gap between treated and untreated wastewater is the biggest challenge for India. Because wastewater is one of the main reasons for water pollution and the degradation of freshwater quality. Hence, this research paper analyse the relationship between population growth and wastewater generation in India.

2. REVIEW OF LITERATURE

Kamble (2022) study analysed the health effects caused due to water pollution. This study found that most of the water pollution occurred due to discharging of domestic and agricultural waste, increasing

urbanization, population growth, over the use of pesticides and fertilizers. The polluted water is spreading bacteria, viral, and parasitic diseases that are affecting human health. The research paper recommends that wastewater should be treated before discharge into waterbodies and made awareness to people for control water pollution.

Bijekar et al., (2022) discussed the emerging trends in wastewater treatment of developing nation. The high population growth, water scarcity, and wastewater management are the challenges for developing nation. The health effect caused due to consumption of unsafe drinking. The study suggested that Government and policymakers must give priority to the development of the civil and IT infrastructure required for wastewater treatment.

Gautam et al., (2017) analysed the water demand, wastewater generation, and treatment status of Delhi. This study found that water demand was rapidly increasing due to the increasing population and only 58 percent of wastewater is treated rest of the wastewater is either directly or indirectly in the natural water resources. The study concludes that reuse and reduce of water must be adopted for reducing the exploitation of natural water resources

Bhardwaj (2005) discussed the State wise and National status of water supply, wastewater generation, treatment, and disposal from Class I cities and Class II towns. The study found that wastewater generation was increased more than three-fold in Class I cities and Class II towns and untreated wastewater also drastically increased. It was directly discharged into waterbodies and indicated the deterioration of water quality. The study suggested to reuse wastewater for agriculture.

3. OBJECTIVE OF THE STUDY

- To examine the relationship between population growth and wastewater generation in India

4. METHODOLOGY

The data for the study pertain to wastewater generation and population growth of India and Class I cities and Class II towns. Therefore, secondary data was collected from *Central Pollution Control Board reports, the World Bank,* the ENVIS Report, *the Centre for Science and Environment (CSE), and the Ministry of Environment, Forest & Climate Change.* For data analysis the Percentage change over the previous year, Correlation, and Linear regression were used for this study.

5.DATA ANALYSIS & DISCUSSION

Table 1: Population Growth and Wastewater Generation in India 2001-2020

(MLD - Million liters per day)

Year	Population (in crores)	% Change over previous year	Wastewater in MLD	% Change over previous year	Treatment in MLD (%)	Untreated in MLD (%)
2001	107.9	-	22,903	-	5,942 (25.94)	16,961 (74.06)
2009	122.36	13.40	38,255	67.03	8,251 (21.57)	30,004 (78.43)
2015	132.29	8.12	61,754	61.43	22,963 (37.18)	38,791 (62.82)
2020	139.64	5.56	72,368	17.19	20,236 (27.96)	52,132 (72.04)

Sources: World bank and CPCB reports 2015, 2020.

The table 1 indicates the population growth and wastewater generation in India from 2001 to 2020. The percentage change over the previous year confirmed that population growth was tremendously increased compared to the previous year. In 2020, population growth was 5.56 percent increase over the previous year. The rise in population growth was increase the water demand for consumption and other basic facilities. Indian cities suffer from lack of infrastructure development and poor sanitation facilities due to unplanned urbanization and high population growth. It creates an aggregate impact generating a huge amount of wastewater. The percentage change over the previous year for wastewater generation shows that in 2009 was 67.03 percent of wastewater generated over the previous year and compared with the previous year, wastewater generation in 2015 was 61.43 percent and in 2020 was 17.19 percent of wastewater generated over the previous year. According to WWAP,

EPRA International Journal of Socio-Economic and Environmental Outlook (SEEO) ISSN: 2348-4101
Volume: 10 | Issue: 6 | June 2023 | SJIF Impact Factor (2023): 8.153 | Journal DOI: 10.36713/epra0314 | Peer-Reviewed Journal

2017 stated that 80 percent of sewage is discharged without treatment the above table also confirmed that 25 - 30 percent of wastewater is treated and the remaining 70 percent of wastewater is untreated.

Table 2: The Population Growth, Water Supply, and Wastewater from Class I cities in India

(MLD - Million liters per day)

Year	Population (In Millions)	% Change over previous year	Water supply in MLD	% Change over previous year	Wastewater Generation in MLD	% Change over previous year	Treatment in MLD (%)	Untreated in MLD (%)
1978	60	-	8638	-	7007	-	2756 (39.33)	4251 (60.67)
1988	102	70.00	15190	75.85	12148	73.37	2495 (20.54)	9653 (79.46)
1995	128	25.49	20607	35.66	18882	55.43	4037 (21.38)	14845 (78.62)
2006	187	46.09	29782	44.52	23826	26.18	6955 (29.19)	16871 (70.81)
2009	227	21.39	44769	50.32	35558	49.24	11554 (32.49)	24004 (67.51)

Source: ENVIS, CSE, CPCB, 2009 and World Bank

The table 2 shows the population growth, water supply, and intensification of wastewater generation from Class I cities in India from 1978 to 2009. The population growth in Class I cities was tremendously increase and in 1988, the percentage change over the previous year was clearly indicated that the 70 percent of population growth was increased in Class I cities over the previous year and it was continuously increase. In 2009, Class I cities population growth was 21.39 percent increase over the previous year. The Government also increases the water supply for people consumption. After consumption more wastewater was generated. The percentage change over the previous year indicates the same result in 1988, 73.37 percent of wastewater was increased than the previous year and it was increase continuously. In 1978, around 40 percent of wastewater is treated, and the remaining 60 percent of wastewater was untreated. In 1988 and 1995 around 20 percent of wastewater is treated and the remaining 80 percent of wastewater was untreated. Due to the implementation of the Sewage Treatment Plant, in 2006 and 2009 the additional 10 percent of wastewater treatment was increased. Therefore, around 30 percent of wastewater was treated in 2006 and 2009.

Table 3: The Population Growth, Water Supply, and Wastewater from Class II towns in India

(MLD - Million liters per day)

Year	Population (in millions)	% Change over previous year	Water Supply in MLD	% Change over previous year	Wastewater Generation in MLD	% Change over previous year	Treatment in MLD (%)	Untreated in MLD (%)
1978	12.8	-	1533	-	1226	-	67 (5.46)	1159 (94.54)
1988	20.7	61.72	1622	5.81	1280	4.40	27 (2.11)	1253 (97.89)
1995	23.6	14.01	1936	19.36	1650	28.91	62 (3.76)	1588 (96.24)
2006	30	27.12	3035	56.77	2428	47.15	89 (3.67)	2339 (96.33)
2009	37.5	25.00	3324	9.52	2696	11.04	233 (8.64)	2463 (91.36)

Source: ENVIS, CSE, CPCB, 2009 and World Bank

The table 3 explains the Class II town's population growth, water supply, and wastewater generation from 1978 to 2009. The population growth was continuously increase in Class II towns. When population growth

EPRA International Journal of Socio-Economic and Environmental Outlook (SEEO) ISSN: 2348-4101
Volume: 10 | Issue: 6 | June 2023 | SJIF Impact Factor (2023): 8.153 | Journal DOI: 10.36713/epra0314 | Peer-Reviewed Journal

increase government also increases the water supply. The water consumed for domestic activities generated the huge amount of wastewater. The percentage change over the previous year of the population growth, water supply, and wastewater generation from Class II towns was continuously increase over the previous year. In Class II town from 1978 to 2009 around 5 - 10 percent of wastewater is treated and around 90 - 95 percent remain as untreated wastewater.

Table 4: Correlation between the Population Growth and Wastewater Generation in India

Correlation Result		*Population Growth*	*Wastewater Generation*
Population Growth	Pearson Correlation	1	.989*
	Sig. (2-tailed)		.011
Wastewater Generation	Pearson Correlation	.989*	1
	Sig. (2-tailed)	.011	
***. Correlation is significant at the 0.05 level (2-tailed)**			

The table 4 reveals that there is a positive relation between population growth and wastewater generation in India and significant at 5 percent level. Every year population growth was increases with excessive water consumption activities which leads to a great extent of water demand for domestic activities and personal hygiene. Therefore, population growth has major relation with wastewater generation in India.

Table 5: Correlation between the Population Growth and Wastewater Generation from Class I cities and Class II towns in India

Correlation Result		*Population Growth of Class I cities*	*Wastewater Generation from Class I cities*
Population Growth of Class I cities	Pearson Correlation	1	.981**
	Sig. (2-tailed)		.003
Wastewater Generation from Class I cities	Pearson Correlation	.981**	1
	Sig. (2-tailed)	.003	
****. Correlation is significant at the 0.01 level (2-tailed)**			
Correlation Result		*Population Growth in Class II towns*	*Wastewater Generation from Class II towns*
Population Growth of Class II towns	Pearson Correlation	1	.947*
	Sig. (2-tailed)		.015
Wastewater Generation from Class II towns	Pearson Correlation	.947*	1
	Sig. (2-tailed)	.015	
***. Correlation is significant at the 0.05 level (2-tailed)**			

The table 5 indicates there is a close and positive correlation between population growth and wastewater generation from Class I cities and Class II towns in India. It was proved by the Correlation result of Class I cities shows both the variables are significant at 1 percent level and in Class II towns also both the variables are significant at 5 percent level. While the population growth is increasing, water demand also increases and after human consumption, a huge amount of wastewater is generated. It was confirmed by the correlation result.

Hypothesis Testing - Linear Regression Result

H_0 - There is no significant relationship between population growth and wastewater generation in India.

H_1 - There is a significant relationship between population growth and wastewater Generation in India.

EPRA International Journal of Socio-Economic and Environmental Outlook (SEEO) ISSN: 2348-4101
Volume: 10 | Issue: 6 | June 2023 | SJIF Impact Factor (2023): 8.153 | Journal DOI: 10.36713/epra0314 | Peer-Reviewed Journal

Table 6: Linear regression of population growth and wastewater generation in India

	Wastewater Generation as the dependent variable			
	Estimate	**Std error**	**t- value**	**Significance**
(Constant)	-150078.066	21506.272	-6.978	.002**
Population Growth	1587.375	170.846	9.291	.011**
R squared	0.977			
Adjusted R Square	0.966			

Note: ** 1% level of Significance

Quadratic Function: $Y = a \pm bx + U$

$Y = a \pm bx_1 + U$

$Y = -150078.066 + 1587.375_{(POP\ G)} + U$

Where Y = Wastewater Generation

a = Constant

X_1 = Population Growth $_{(POP\ G)}$

U = Error term

The table 6 depicts the linear regression analysis of population growth and wastewater generation in India. The R square value is 0.977 and it indicates that 97 percent of (dependent variable) wastewater generation is influenced by the independent variable population growth of India. The regression result reveals that population growth was statistically significant at 1 % level. Therefore, H_0 is rejected at 1% level and accepts the H_1. There is a significant relationship between population growth and wastewater generation in India.

Table 7: Linear regression of population growth and wastewater generation from Class I cities in India

	Wastewater Generation as the dependent variable			
	Estimate	**Std error**	**t- value**	**Significance**
(Constant)	-3397.450	2807.304	-1.210	.001**
Population Growth	162.512	18.361	8.851	.003**
R squared	0.963			
Adjusted R Square	0.951			

Note: ** 1% level of Significance

$Y = a \pm bx_1 + U$

$Y = -3397.450 + 162.512_{(POP\ G)} + U$

Where Y = Wastewater Generation from Class I cities

a = Constant

X_1 = Population Growth $_{(POP\ G)}$ of Class I cities

U = Error term

The table 7 represents the linear regression analysis of population growth and wastewater generation from Class I cities in India. The R square value is 0.963 and its indicates that 96 percent of (dependent variable) wastewater generation from Class I cities was determined by population growth of Class I cities in India and statistically significant at 1 % level.

Table 8: Linear regression of population growth and wastewater generation from Class II towns in India

	Wastewater Generation as the dependent variable			
	Estimate	**Std error**	**t- value**	**Significance**
(Constant)	163.100	349.940	0.466	.006**
Population Growth	67.933	13.311	5.103	.015**
R squared	0.897			
Adjusted R Square	0.862			

Note: ** 1% level of Significance

$Y = a \pm bx_1 + U$

$Y = 163.100 + 67.933_{(POP\ G)} + U$

Where Y = Wastewater Generation from Class II towns
a = Constant
X_1 = Population Growth $_{(POP\ G)}$ of Class II towns
U = Error term

The table 8 reveals that linear regression analysis of population growth of Class II towns in India and wastewater generation are statistically significant at 1 % level. The R square value is 0.897 and it indicated that 89 percent of wastewater generation from Class II towns was influenced by population growth.

Effect of wastewater discharge in Environment

Wastewater is largely produced due to human activities and it was a reverse effect on human health and also a negative externality to the whole biodiversity. Because, the untreated wastewater directly is discharged into waterbodies, it affected the freshwater ecosystem, rising water scarcity and the consumption of contaminated water, increase the health cost to society in the form of waterborne diseases. The wastewater is not only affected the surface water and also affected the groundwater and soil quality. So, the wastewater is one of the biggest Environmental issues.

6. CONCLUSION

This study found that there is a strong link between population growth and wastewater generation in India. The population growth in India was continuously increasing year by year and the water demand for consumption also increase due to the continuous rise in population. It resulted, the huge amount of wastewater generation in India. This will reflect the massive growth of population and waste generation in the upcoming years. So far, around 30 percent of wastewater is only treated, and the remaining untreated wastewater is either directly or indirectly discharged into freshwater bodies. It creates water pollution, scarcity of fresh water, and increase health costs to society. Therefore, the research paper recommends to the Government should make concerned about wastewater treatment and regulation of wastewater treatment plants and create awareness among people about reusing the treated wastewater and reduce water consumption to protecting the freshwater resources for the present and future generations.

REFERENCES

1. *Basu., S. (2013). Unsafe water stunting growth of Indian children: report. Down to Earth, 18 Feb 2013. https://www.downtoearth.org.in/news/unsafe-water-stunting-growth-of-indian-children-report-40391*
2. *Bhardwaj, R.M. (2005). Status of Wastewater Generation and Treatment in India. IWG-Env, International Work Session on Water Statistics Vienna, 20-22.*
3. *Bijekar, S., Padariya, H. D., Yadav, V. K., Gacem, A., Hasan, M. A., Awwad, N.S., Yadav, K.K., Islam, S., Park, S., Jeon, B. H. (2022). The State of the Art and Emerging Trends in the Wastewater Treatment in Developing Nations. Water, 14(16), 2537. https://doi.org/10.3390/w14162537*
4. *CPCB. (2015). Inventorization of Sewage Treatment Plants. Central Pollution Control Board. http://nrcd.nic.in/writereaddata/FileUpload/NewItem_210_Inventorization_of_Sewage-Treatment_Plant.pdf*
5. *CPCB. (2016). CPCB Bulletin. Central Pollution Control Board, https://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS9MYXRlc3RfMTIzX1NVTU1BUllfQk9PS19GUy5wZGY*
6. *CPCB. (2021). National Inventory of Sewage Treatment Plants. Pollution Control Board, Ministry of Environment Forest, and Climate Change (MoEFCC), New Delhi.*
7. *CPHEEO. (2012). Manual on Sewerage and Sewage Treatment. Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, New Delhi, India.*
8. *EIACP Programme Centre on Hygiene, Sanitation, Sewage Treatment Systems and Technology. National status of waste water generation & treatment. http://www.sulabhenvis.nic.in/database/stst_wastewater_2090.aspx*
9. *Gautam, R. K., Islamuddin, M. N., Verma, S., Pandey, S., Mumtaz, N., Kumar, R., & Usama, M. (2017). Sewage Generation and Treatment Status for the City of Delhi, its Past, Present and Future Scenario- A Statistical Analysis. International Journal for Research in Applied Science and Engineering Technology, 5 (v), 926-933.*
10. *India's sewage treatment plants treat only a third of the sewage generated daily: CPCB, Down to Earth, 22 September 2021. https://www.downtoearth.org.in/news/waste/india-s-sewage-treatment-plants-treat-only-a-third-of-the-sewage-generated-daily-cpcb-79157*
11. *Jaysawal, N., Saha, S. (2014). Urbanization in India: An Impact Assessment. International Journal of Applied Sociology, 4(2), 60-65. DOI: 10.5923/j.ijas.20140402.04*
12. *Kamble, M. A. C. (2022). Health Effects of Water Pollution. EPRA International Journal of Economic and Business Review (JEBR), 10(9), 45-50.*

13. *Schellenberg, T., Subramanian, V., Ganeshan, G., Tompkins, D., & Pradeep, R. (2020). Wastewater discharge standards in the evolving context of urban sustainability – The case of India. Frontiers in Environmental Science, 30.*
14. *Sustainable Development Goals. https://www.un.org/sustainabledevelopment/water-and-sanitation/*
15. *UN WWAP (United Nations World Water Assessment Programme) (2017). The United Nations World Water Development Report (2017). Wastewater: The Untapped Resource. Paris: UNESCO.*
16. *Urban Wastewater Scenario in India (2020). NITI Aayog and Atal Innovation Mission https://aim.gov.in/images/Waste-Water-ver2_18102022.pdf*
17. *Wastewater management framework in India: Policy challenges and solutions for a sustainable future (2022). https://www.indiawaterportal.org/articles/wastewater-management-framework-india-policy-challenges-and-solutions-sustainable-future*
18. *World bank (2013). India Diagnostic Assessment of Select Environment challenges.*

    https://openknowledge.worldbank.org/bitstream/handle/10986/16028/700040v20ESW0P0box0374379B00PUBLIC0.pdf?sequence=1&isAllowed=y
19. *http://cpcbenvis.nic.in/cpcb_newsletter/sewagepollution.pdf*
20. *https://pib.gov.in/Pressreleaseshare.aspx?PRID=1779799*

Acknowledgement

I express gratitude to my research supervisor Dr. R. Manikandan for his guidance and genuine thanks to Dr. Ambedkar International Centre for being granted Dr. Ambedkar Doctoral fellowship for my research work.