International Journal of Health Sciences and Research
Vol.13; Issue: 9; September 2023
Website: www.ijhsr.org
Review Article *ISSN: 2249-9571*

An Analysis of Cancer Causing Agents and Its Association with the Prevalence of Cancer Cases in Noyyal River Basin, Tamil Nadu, India - An Explorative Study Based on Scientific Evidences

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DOI: https://doi.org/10.52403/ijhsr.20230932

ABSTRACT

Water is one of the most crucial factors determining the quality of life of the people. The objective of the study is to find whether there is any association between the presence of carcinogens in Noyyal river basin in Coimbatore and Tirupur and increase in the number of cancer cases in the cities. Carcinogens were identified based on "International Agency for Research on Cancer" lists of carcinogens with cancer site. The cross-sectional studies included in the study are from the year 2009 to 2022. The concentration of potential carcinogens such as cadmium, hexavalent chromium, nickel, lead, arsenic, nitrite/nitrate and phosphates are evaluated. Their levels were compared with WHO standard limit for drinking water. Tamil Nadu Cancer Registry Project report 2021 was used to calculate the percentage of cancer cases reported in each district contributing to the overall Tamil Nadu. The results show that Noyyal is highly contaminated to the extent where aquatic organisms show up critical levels of heavy metal. Government should respond to the perilous situation where drinking water and human consuming foods are suffused with carcinogens.

Keywords: Heavy metals, Carcinogens, Industrialization, Water Pollution, Cancer.

INTRODUCTION

The agenda adopted by United Nations member states in 2015 for Sustainable Development, Goal 6 is to ensure availability and sustainable management of water and sanitation for all by 2030. Recently, track progress for the same was released by General Assembly Economic and Social Council, where 2.2 billion people lacked safe drinking water, 3.4 billion people lacked basic sanitation, and 1.9 billion people lacked basic hygiene in 2022. As we are at the mid of 2030 Agenda, we are not on track to meet most of the Goals by 2030. [1] Industrial wastes and improper discharge of untreated effluents into rivers and canals are the main reason for the groundwater contamination. These industrial effluents not only contaminate the groundwater but also disperse into the air polluting atmosphere as well as discharged randomly into soil. Commonly, contaminated water is associated with various communicable diseases such as cholera, diarrhea and dysentery. Inadequately treated waste water from industries, agriculture and domestic purposes contaminates the source of drinking water of many habitants. Most important chemical risks in drinking water

sources such as cadmium, chromium, lead, arsenic, nickel, nitrite/nitrates and phosphates are known to be a potential human carcinogen.

River Noyyal meaning 'void of illness' is considered to be the sacred river for people dwelling in Coimbatore and Tirupur districts, Tamil Nadu state, India. Literally, the meaning of the term 'Noyyal' is changing now-a-days after urbanization and as population rise hits its new height. Coimbatore, hub of textile industry celebrated as "Manchester of Tamil Nadu." Government owned SIDCO at Kurichi, motor-pump industries and renowned 'Coimbatore wet grinders.' World famous textile research institutes 'Central Institute for Cotton Research (CICR)' has its Southern Regional Station in Maruthamalai road and South Indian Textiles Research Association (SITRA) located in Avinashi road at Coimbatore district. Coimbatore is not just the hub of textile industries but also serves as a home for various other small scales industries such as cast manufacturing units at Malumichampatti. Agriculture is one of the major occupations for the natives. The fledging IT industry in Coimbatore district is promising to be its next textile mart. Tirupur is colloquially called as 'Baniyan city of Tamil Nadu.' Tiruppur contributed nearly 54.2% of India's textile exports in FY22. Their contribution to the growth of nation' economy is phenomenal but at the cost of so many innocent lives.

Researches to date has identified potential carcinogens in the water and soil samples collected in and around Coimbatore, Tirupur, River Noyyal itself and its sediments. The purpose of this study is to find whether there is any association between the presence of carcinogens and increase in number of cancer cases in the city. Since cancer is a multifactorial disease, the study aims to shed light on environmental hazards which can be possible contributing factors in the development and progression of cancer among those with no deleterious habits like smoking, alcohol and genetical mutation.

MATERIALS & METHODS

Information sources: In assent with PRISMA guidelines, the following electronic databases were searched from 2009 until 2022: PubMed, Wiley online library, Elsevier science direct, SpringerLink, ResearchGate and Medline.

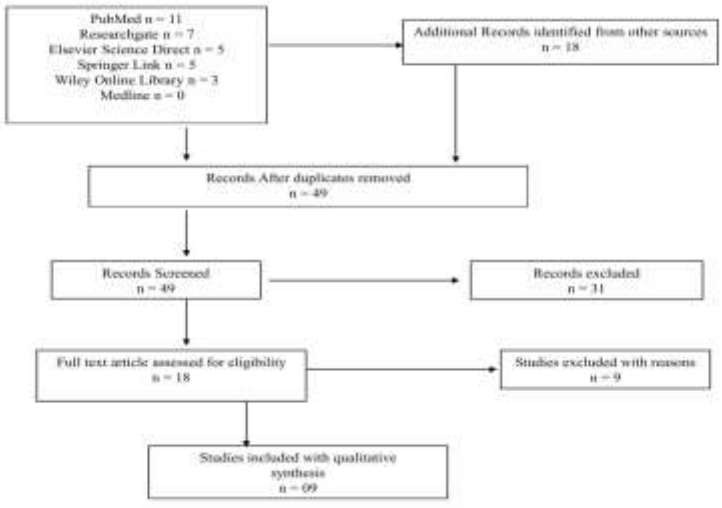


Figure 1: Flow diagram showing the number of studies identified screened assessed for eligibility excluded and included in systematic review.

Search Strategy: The search strategies included Boolean operators for the following combinations of keywords: 'Noyyal' or 'Cancer' or 'Environmental toxicity' or 'carcinogens' or 'heavy metal intoxication' or 'toxic pollutants' or 'heavy

metal status' or 'Industrial contaminants' or 'Occupational exposure' or 'water pollution' or 'soil pollution' or 'industrial effluents.'

Inclusion criteria: We included studies conducted in Noyyal river and the respective districts supplied by them as well as those available electronically. Original studies that were published in English with available full-text were included. Studies that used standardized methods of measurements and validation tools were included in the study. Studies that have been carried out with appropriate statistical analysis had included in the study.

Exclusion criteria: Exposure to toxic substances occurred due to accidental spillage were excluded from the study. Studies undertaken by Tamil Nadu Pollution Control Board were excluded.

Data extraction and synthesis: For studies that met the eligibility criteria, the following data was collected: Citation (author/year), study area, study duration, number and type of samples (air/water/soil) collected, carcinogens found in the samples, method of testing samples and test result values. The values were compared with standardized normal limits set by WHO/BIS/CEQG for drinking water source, air and soil. Quality assessment was carried out using Newcastle Ottawa Scale.

METHODOLOGY

We used IARC lists of classification of carcinogens, Volumes 1-133, to enumerate the group of carcinogens along with the cancer site. [2] Carcinogens exceeding the standard limit were checked for its carcinogenic potential and cancer sites showing sufficient and limited evidences in humans by IARC lists of classification of carcinogens and by cancer site respectively. [3] An analysis of the percentage of all types of cancer cases reported in the districts Coimbatore and Tirupur, where Noyyal flows, was conducted using the Tamil Nadu Cancer Registry Project report 2021, published by the Cancer Institute, Adyar and the state health department. [4] The percentages obtained were then used to find the association between the excessive presence of carcinogens and their contribution to the increased prevalence of cancer. Tamil Nadu average count for each district were calculated by adding number of cancer cases of specific type in all the districts divided by 38 (total 38 districts in Tamil Nadu state).

RESULT

Table 1: Review of articles on the presence of carcinogenic agents in the Noyyal river basin, its method of assessment and the results obtained.

Author Year of Publication Place of Study	Study Duration	Methods of Measurements	Sample Size & Sample Site	Carcinogen	Results	Normal Permissible Limit (PL)
Sherene T et al; 2009 Coimbatore [5]		Atomic absorption spectrophotometer.	50 soils samples 5 sites – electroplating industries, textile industries, casting industries, foundries, sewage water field.	Cadmium Nickel Lead Chromium	0.3-4.6 mg/kg 3.0-157.0 mg/kg 7-170 mg/kg 3.3-593.99 mg/kg	0.01- 1mg/kg with mean 0.36mg/kg 20 – 30 mg/kg 15 - 40 mg/kg 14 – 70 mg/kg
Vinu Radha R et al; 2014 Coimbatore [6]		Atomic absorption Spectrophotometer	26 soils samples Sewage area – 0-15cm depth.	Cadmium	>3 mg/kg in 5 sites	0.5 mg/kg soil (Statutory order 49/2000).
Mohan Kumar K et al 2016	May – June, 2018.	Atomic absorption Spectrophotometer using Perkin	4 groundwater sample from	Arsenic Cadmium	Near kurichi industrial area - <BDL Away from residential	0.001mg/L(DL) WHO, 0.01 mg/L(PL)

Coimbatore [7]		Elmer AA 200 Model.	Singanallur, Saibaba Colony, Gandhipuram, Selvapuram. SIPCOT HOUSING UNIT 1, 11, LIC colony, Echanari.		area Singanallur(13km)- 0.0014mg/L Gandhipuram(10.1km)- 0.0010mg/L Saibaba colony(10.1km)-BDL Selvapuram(8.6km)- 0.002mg/L Singanallur-0.002mg/L	DL-0.01mg/L WHO-PL- 0.005mg/L
Manikandan R et al 2016 Coimbatore [8]	Sep 2012 – Aug 2013	Atomic absorption flame emission Spectrophotometer AAFES - 6200	Surface water samples at 500m distance from Ukkadam Kuruchi Singanallur	Cadmium Lead Chromium	Ukkadam – 0.015-0.038mg/l Kuruchi – 0.014-0.038mg/l Singanallur – 0.014-0.037mg/l Ukkadam – 0.061-0.463mg/l Kuruchi – 0.481-0.569mg/l Singanallur- 0.492-0.531mg/l Ukkadam – 0.031-0.059mg/l Singanallur – 0.047-0.063mg/l	WHO - 0.003mg/L WHO-0.010mg/l WHO- 0.050mg/l
Babunath R et al 2017 Coimbatore Tirupur [9]	July 2008-June 2009	Atomic absorption Spectrophotometer Varian Techtron, AA-6D	River and sediment samples collected every month from Chadivayal Mangalam, Anakuli Orathupalayam Noyyal village	Water: Cadmium Lead Chromium Sediments: Cadmium Lead Chromium	0.192-1.428 mg/l 0.326-1.503 mg/l 1.484-4.045 mg/l 0.591-1.051mg/kg 0.552-1.1978mg/kg 1.621-3.013mg/kg	BIS- 0.01 mg/l BIS- 0.1 mg/l BIS- 0.05 mg/l
Sajil Kumar Pazhuparambil Jayarajan et al 2020 Coimbatore Tirupur [10]	July 2016	Ion chromatography	93 ground water samples From borewells in Coimbatore and Tirupur	Nitrates	1-415mg/l with average -77mg/l	WHO – 50mg/l (2017); IS - 45mg/l
Arumugam K et al; 2020 Tirupur [11]		Standard methods given by APHA 1995	62 ground water samples from boreholes -Avinashi & Palladam	Nitrates	0-572mg/l with mean – 78mg/l	WHO – 50mg/l (2017); IS - 45mg/l
Gayathri V et al 2020 Noyyal Chinnar rivers [12]	Feb – Mar, 2018	Atomic absorption Spectrophotometer AA-7000	3 water and sediment samples at 15 days interval. 20 S. Hydrodroma 15 B. Cunicularis from Noyyal Chinnar rivers	Nitrates Cadmium Lead	Water – Noyyal- 250±4.20mg/l Chinnar-5.0±0.40mg/l Water – Noyyal- 0.02±0.001mg/l Chinnar- 0.01±0.004mg/l Tested organ- S. Hydrodroma- 0.09-0.027mg/kg B. Cunicularis- 0.05-0.17mg/kg Water – Noyyal- 10.74±0.550mg/l Chinnar- 8.86±0.30mg/l Sediments – Noyyal – 13.51±0.55mg/kg; Chinnar – 11.15±0.32mg/kg Tested organ - S. Hydrodroma- 17.87-21.32mg/kg B. Cunicularis- 9.48-10.59mg/kg	BIS – 45mg/l (2012) BIS – 0.003 mg/l USEPA- 0.01 mg/l(2002) FAO – 0.05mg/kg(1983) MPEDA – 3.0mg/kg(2012) BIS – 0.01 mg/l USEPA- 0.05 mg/l USEPA- 10mg/kg FAO – 0.5mg/kg MPEDA – 1.5mg/kg

Karunanidhi D et al 2022 Noyyal [13]	May 2019 (pre-monsoon) Jan 2020 (post-monsoon)	Atomic absorption Spectrophotometer using Perkin Elmer AA 700 Model.	130 river waters samples Noyyal Region 1- Coimbatore Region 2- Tirupur Region 3- Erode Region 4- Karur	Cadmium	Pre- monsoon: Region1:0.001-0.078 Region2:0.003-0.124 Region3:0.021-0.874 Region4:0.001- 0.052 Post- monsoon: Region1:0.001-0.030 Region2:0.001-0.101 Region3:0.002-0.572 Region4:0.001- 0.035	WHO - 0.003mg/L
				Nickel	Pre- monsoon: Region1:0.001-0.120 Region2:0.001-1.145 Region3:0.006-0.070 Region4:0.001- 0.065 Post- monsoon: Region1:0.001-0.098 Region2:0.001-0.512 Region3:0.001-0.050 Region4:0.001- 0.045	WHO- 0.010mg/l
				Lead	Pre- monsoon: Region1:0.001-0.142 Region2:0.001-1.214 Region3:0.010-0.544 Region4:0.001- 0.178 Post- monsoon: Region1:0.001-0.100 Region2:0.001-0.870 Region3:0.001-0.348 Region4:0.001- 0.126	WHO- 0.010mg/l
				Chromium (mg/l)	Pre- monsoon: Region1:0.010-1.740 Region2:0.048-1.547 Region3:0.021-1.587 Region4:0.001- 0.921 Post- monsoon: Region1:0.010-1.210 Region2:0.001-1.240 Region3:0.018-1.247 Region4:0.012- 0.871	WHO- 0.050mg/l

TABLE 1 shows the review of articles on method of measurement of particular carcinogen and the results obtained at particular site as given by Sherene T et al, Vinu Radha R et al, Mohan Kumar K et al, Manikandan R et al, Babunath R et al, Sajil Kumar Pazhuparambil Jayarajan et al, Arumugam K et al, Gayathri V et al and Karunanidhi D et al.

TABLE 2: Percentage of cancer cases and its association with carcinogen levels in the Noyyal river.

District	Carcinogens	Mean range obtained[a]	Normal value[b]	Cancer site[c]	Percentage of cancer cases[d]
Noyyal: Coimbatore Tirupur	Nickel (soil)	3.0-157.0	20 – 30	Nasal cavity and paranasal cavity & Lung	COIMBATORE: Prostate - 7.7% Lung – 6.9% Liver - 6.7% Nasal cavity - 6.3% Kidney - 5.1% Skin - 4.8% Bladder - 3.9% Stomach – 3.1% TIRUPUR: Lung – 3.2% Prostate – 2.9% Kidney – 2.9% Stomach – 1.6% Nasal cavity– 1.3%
	Nickel (water)	0.001-1.214	0.010		
	Chromium (soil)	3.3-593.99	14 – 70	Nasal cavity and paranasal cavity & Lung	
	Chromium (water)	0.031-4.045	0.05		
	Cadmium (soil)	0.3-4.6	0.5	Lung, Prostate & Kidney	
	Cadmium (water)	BDL-1.428	0.003		
	Nitrate (water)	1-572	45	Stomach	
	Arsenic (water)	BDL-0.0014	0.01	Bladder, Lung, Skin, Prostate, Kidney & Liver	
	Lead (soil)	7-170	15 - 40	Stomach	
	Lead (water)	0.061-11.54	0.010		

TABLE 2 represents the spurts of cancer cases in the districts that lie along Noyyal river basin.

Source: [a]Mean value of carcinogens was the cumulated score of different studies

described in the Table 1; Units: water-mg/l; soil-mg/kg.

[b]Mean score was compared with WHO 2013 standard limits for drinking water; Units – mg/l.

[c]Cancer site – Individual risk of cancer for each carcinogen was noted with the reference from "List of classifications by cancer sites with sufficient or limited evidence in humans, IARC Monographs Volumes 1-132. WHO 2022[3]"

[d]Percentages of cancer cases – TNCRP 2021 report. Percentages of cancer cases were calculated based on the number of cancer cases reported in TNCRP 2021[4]

TABLE 3: Quality Assessment-Newcastle Ottawa scale

AUTHOR & YEAR	SELECTION				COMPARABILITY	OUTCOME	
	Representativeness of the samples	Sample size	Non-respondents	Ascertainment of the exposure		Assessment of the outcome	Statistical test
Sherene T et al, 2009 [5]	*	*	-	**	*	**	*
Vinu Radha R et al, 2014 [6]	*	*	-	**	*	**	*
Mohan Kumar K et al, 2016 [7]	*	-	-	*	*	**	-
Manikandan R et al, 2016 [8]	*	*	-	**	*	**	*
Babunath R et al, 2017 [9]	*	*	-	**	*	**	*
Sajil Kumar Pazhuparambil Jayarajan et al, 2020 [10]	*	*	-	**	*	**	*
Arumugam K et al, 2020 [11]	*	*	-	**	*	**	*
Gayathri V et al, 2020 [12]	*	*	-	**	*	**	*
Karunanidhi D et al, 2022 [13]	*	*	-	**	*	**	*

ANALYSIS:

FIGURE 2: Graphical representation of heavy metal concentration in soil in Noyyal river as such along with Coimbatore-Tirupur districts with normal limit of WHO standards.

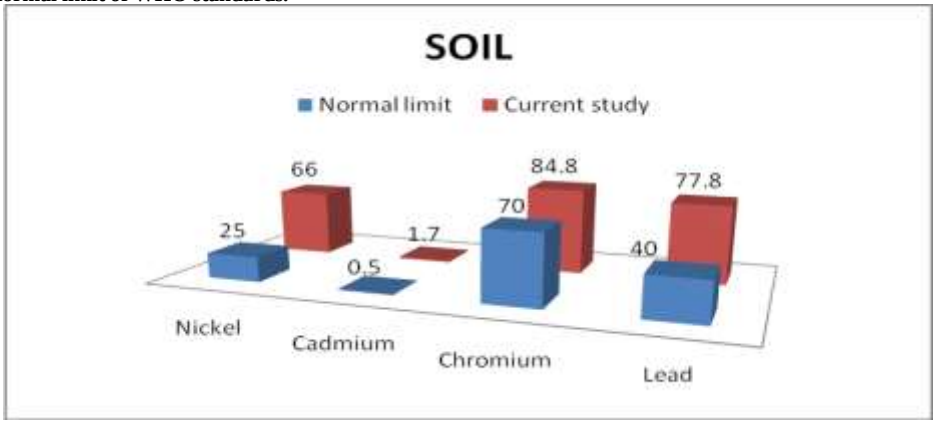


FIGURE 3: Graphical representation of heavy metal concentration in water in Noyyal river as such along with Coimbatore-Tirupur districts with normal limit of WHO standards.

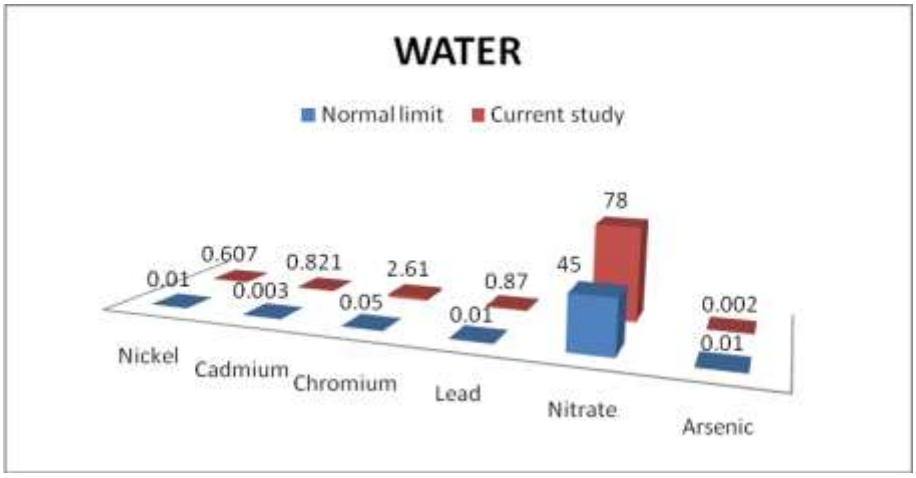


FIGURE 4: Graphical representation of cancer cases recorded in the Coimbatore district compared with Tamil Nadu Average count.

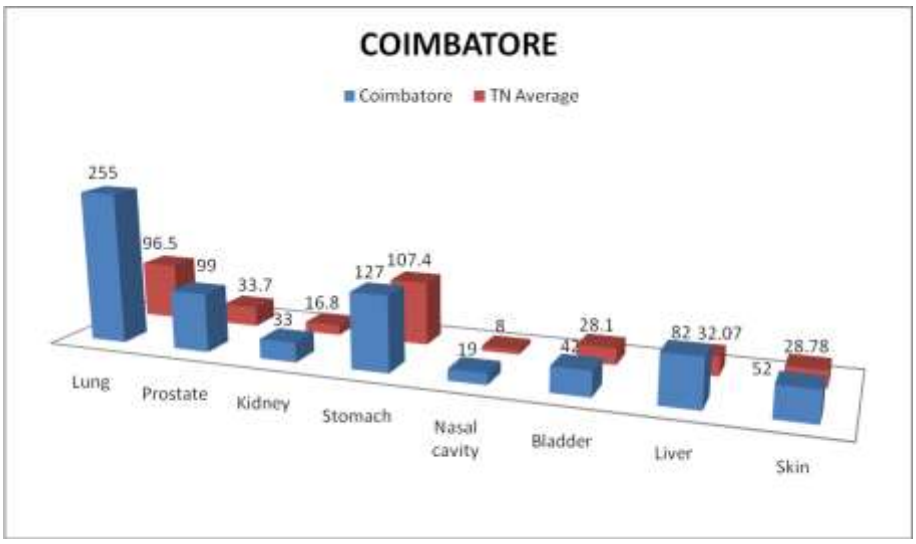
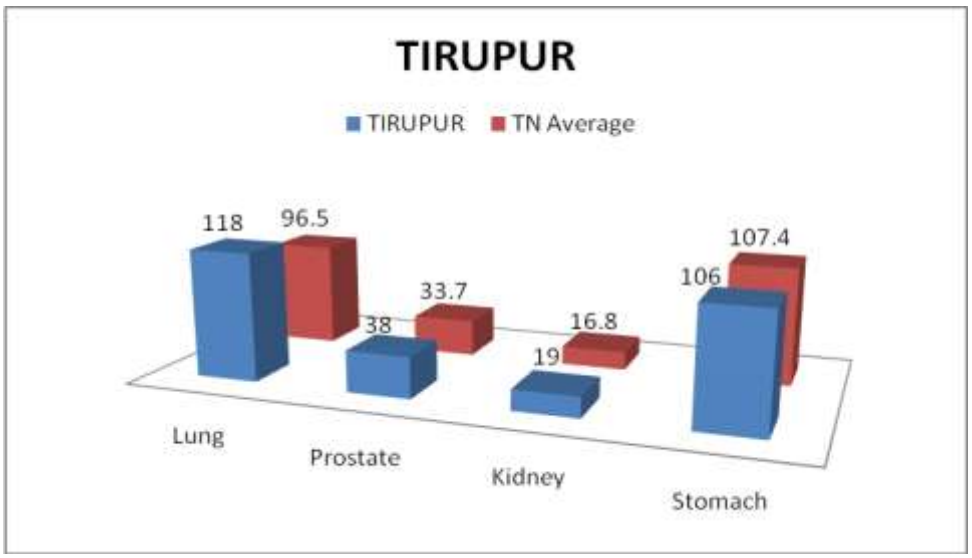


FIGURE 4: Graphical representation of cancer cases recorded in the Tirupur district compared with Tamil Nadu Average count.



DISCUSSION

"Surfactant from untreated domestic sewage main reason for frothing in River Noyyal" was the latest headlines in the leading newspaper. The lead of the news went on a way stating that the reason behind frothing was due to anthropogenic activities like washing clothes, bathing using detergents and soaps with high levels of surfactant. According to the test run by Tamil Nadu Pollution Control Board, the samples collected from Pattanam Pudur showed 0.8mg/l of surfactant against normal level of 0.2mg/l. District Environmental Engineer denied the allegations against dyeing industries and claimed that the contamination is purely due to domestic activities.[14] More reliable research on the same has to be carried by Non-Governmental Organizations, volunteers or educational institutes.

Carcinogenic risk assessment signified high cancer risk in Coimbatore district during pre-monsoon season and in Tirupur during post-monsoon season. [12] Misery index of a country directly influences on the Human Development Index (HDI) and hence on the health indicators. Higher the misery index score lower will be the HDI and quality of life. [15] Sajil Kumar et al, 2021 study showed wide variations of nitrate levels primarily attributed by overuse of agricultural fertilizers and due to leaks in urban sewage and septic tanks. Mini sewage treatment plants, material recycling, thermal treatments incineration, biogas generation and composting can be implemented for the proper disposal of domestic and municipal waste. [10] Gayathri V et al, 2020 showed the shocking findings of crabs tested positive for heavy metal toxicity. On consumption, the toxicity easily gets into the food chain and causes deleterious effects including cancer in human.[13] Food Safety Department should ensure that foods such as fruits, vegetables, nuts and species are not contaminated with either fertilizers or pesticides. Entomology/Toxicology Department of Agriculture should monitor the overuse of fertilizers and pesticides by farmers. Introduction of eco-friendly natural pesticides is a healthy method of pest control system. [16] Mohan Kumar et al, 2016 suggested the working model for reducing the Environmental Pollution Index, where implementation of Zero waste strategy, Reverse Osmosis system, Water Treatment Plants and Rain water Harvesting System showed successful reduction in the pollution level at Kurichi Industrial Cluster. [7] As childhood exposure to heavy metals like lead, cadmium, arsenic and children showing up of increased levels of these metals in the blood underscore the need of taking immediate remediation measures. Remediatory process includes supplementation of appropriate antagonist for every heavy metal.

Oral manifestations commonly elicited in cases of chronic toxicity of heavy metals such as Cadmium may present as Bone resorption and Osteoporosis and sometimes cause yellowing of teeth; Chromium as Oral Lichenoid Reaction, Lichen Planus, Erosion and discolouration of the teeth, Gingivitis and Periodontitis; Arsenic may present as Rain-drop pigmentation, Hyperpigmentation, Hyperkeratosis, also causes Squamous Cell Carcinoma and Basal Cell Carcinoma; Nickel causes hypersensitivity reactions and lead may induce chronic plumbism metallic taste, lead hue and astringency.

As per Agency for Toxic Substances and Disease Registry (ASTDR) Toxicology profiles, best antidotes for lead are iron [17], calcium, zinc and vitamin C which are rich in nuts & seeds, oranges, grapes, watermelon, greens, tomato, potato, broccoli, cabbage, lady's finger, fish, meat, liver and dairy products. In case of chromium VI toxicity, calcium and magnesium rich in broccoli, cabbage, lady's finger, bananas, oranges and dairy products should be included more in diet. For chronic nickel intoxication, iron and magnesium rich foods greens, beans, peas, bananas, nuts & seeds, liver and dairy products are best counterparts. Similarly, for chronic arsenic poisoning, vitamin A, B9, E and selenium

[18,19] rich papaya, watermelon, wheat germ, nuts & seeds, carrots, greens, sweet potato, broccoli, pumpkin, cauliflower, spinach, chick peas, peas, brown rice, eggs, chicken, liver, fish and dairy products are advised to be added in the diet. Antidotes for cadmium are iron and zinc, rich in greens, nuts & seeds, liver, fish, meat and dairy products. [20]

There is a research gap in the collection of site/zone/area specific samples and the availability of cancer case records only for the entire district, which prevents generalization of the study. Due to the multifactorial nature of cancer, more precise studies are expected in the future, despite limited data.

CONCLUSION

Study results indicate that when carcinogenic compounds are highly concentrated, there is a high rate of cancer incidence. It is imperative that the government addresses this issue immediately and gets the pollution control board, the public health works department and the department of food safety involved in monitoring the situation and ensuring the safety of the population.

Declaration by Authors

Ethical Approval: Not Applicable

Acknowledgement: None

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Sujitha S, Prabu D, Dinesh Dhamodhar, Rajmohan M, Sindhu R. An analysis of cancer causing agents and its association with the prevalence of cancer cases in Noyyal river basin, Tamil Nadu, India - an explorative study based on scientific evidences. *Int J Health Sci Res.* 2023; 13(9):215-224. DOI: *https://doi.org/10.52403/ijhsr.20230932*

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