Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X

Volume 7 Issue 29 (September 2022) PP. 139-151
DOI 10/35631/JTHEM.729011

JOURNAL OF TOURISM, HOSPITALITY AND ENVIRONMENT MANAGEMENT (JTHEM)
www.jthem.com

GLOBAL ACADEMIC EXCELLENCE

RIVER POLLUTION: A MINI REVIEW OF CAUSES AND EFFECTS

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Article Info:

Article history:
Received date: 30.07.2022
Revised date: 08.08.2022
Accepted date: 30.08.2022
Published date: 09.09.2022

To cite this document:

Saad, A. M., Asari, F. F. A. H, Affandi, S., & Zid, A. (2022). River pollution: A Mini Review Of Causes And Effects. *Journal of Tourism Hospitality and Environment Management*, *7* (29), 139-151.

DOI: 10.35631/JTHEM.729011.

Abstract:

Pollution of rivers is a serious topic that is frequently brought up by people from all walks of life all around the world including Malaysia. Domestic wastes, industrial pollutants, as well as agricultural wastes, including harmful and dangerous materials, have been discharged into the rivers directly or indirectly. The inflow of these hazardous pollutants not only pollutes river water but also sediment and aquatic life. Rivers, as we all know, are one of the contributors to the clean water supply in most parts of the world. River pollution has an impact on the availability of clean water used for a range of purposes, including domestic, industrial, and agricultural. Pollution, on the other hand, depletes the supply of food derived from rivers, such as fish and shrimp. The health of users, including humans, animals, and plants, will be affected by the consumption and usage of water, as well as the aquatic life of contaminated rivers. This article exposes the harsh reality of river pollution that we must all accept. To protect our rivers, it is critical to determine and know exactly the pollution sources, causes, and effects of the contaminants on rivers' ecosystems, humans, and animals. When it comes to reducing current river pollution, prevention measures such as public awareness and continuous monitoring are preferable to treatment. In addition, significant research in the area of wastewater monitoring, as well as strict regulations, are required to manage global river pollution. This is important to prevent the continuous pollution of our rivers, which is primarily the result of negligent human actions. For rivers that have been identified as polluted, water treatment technologies including ozonation, chlorination, and aerobic granulation can be applied to remediate the pollutant residues. This is to ensure that the global community receives a clean and safe water supply.

Journal of Tourism, Hospitality and Environment Management JTHEM
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DOI 10/35631/JTHEM.729011

Keywords:

River, Pollution, Garbage, Sewage, Toxic Waste

Rivers: The Treasures

Rivers are one of our most significant sources of freshwater worldwide (Yu et al., 2022; Luo et al., 2021). In most countries, river water is used for drinking and other household daily activities such as washing, cleaning, and cooking. Rivers also play an essential part in the country's agricultural economy (Zhang et al., 2022). Rivers provide water for irrigating paddy fields, sugarcane plants, and cotton crops to ensure handsome profits from the yields (Prajapati, 2022). In addition, river water is, in reality, the lifeblood of the livestock sector for multiple uses throughout the dairy operations, including feedlots and farm hygiene. Aside from that, the oil palm processing industries, rubber manufacturing sectors, pulp and paper industries, and textile production, for example, require access to ample freshwater sources (Tripathy et al., 2022; Weerasooriya et al., 2021). As we know, rivers serve as a vital connector for rural populations, in particular waterways to the nearby town for their core transportation. Furthermore, the clean and appealing river serves as a habitat for aquatic lifelike fish, shrimp, and crabs, which provide a source of cash for the local community, as well as locations for public recreation and sporting activities such as kayaking and canoeing (Liu et al., 2022; Ferreira et al., 2021).

However, anthropogenic activities, such as agriculture and animal husbandry, as well as the use of the urban area for housing or industry, have had a particularly severe impact on the river environment in depth and continuously (Yang et al., 2022). The situation in most rivers, where water quality is deteriorating due to pollution from multiple sources, is extremely concerning and requires immediate attention (Qazi et al., 2022). River management is a complicated issue since the river should not only be used as a tool or resource to meet the community's numerous requirements, but its long-term viability should also be ensured, and the entire community should be involved (Will et al., 2021; Angriani et al., 2018). As a result, the purpose of this article is to illuminate the many causes and impacts of river pollution. Finally, the compilation of pollution sources, causes, and effects discussed in this article might serve as a resource for all parties. This is a tiny effort by the authors to raise awareness among ourselves and society about the significance of preventing constant pollution of these natural riches and ensuring the survival of our rivers, which are our treasures.

What is River Pollution?

River pollution can be defined as the presence or intrusion of pollutants such as garbage, toxic waste, pesticides, and other hazardous residues. The origins of these pollutants are either from point sources or non-point sources via terrestrial or air drift into the river system where the existence of these compounds can alter and degrade river water and bed sediment properties, including physicochemical characteristics (e.g. changes in temperature, pH, dissolved oxygen), biological (e.g. presence of harmful microorganisms), chemical (e.g. accumulation of heavy metals, persistent organic pollutants), and even flora and fauna inhabiting river ecosystems are adversely affected by this situation (Namara et al., 2022; Du et al., 2022; Bhat et al., 2022). Because of the river's pollution, river water, sediment, and aquatic life will no longer be safe

Journal of Tourism, Hospitality and Environment Management
EISSN: 0128-178X
JTHEM
Volume 7 Issue 29 (September 2022) PP. 139-151
DOI 10/35631/JTHEM.729011
to drink, eat, or use for daily activities, putting the health of its users, including humans, animals, and plants, at risk (Xu et al., 2022; Sarkar et al., 2022; Ali et al., 2022).

Causes and Effects of River Pollution

Various activities that occur either anthropogenically or naturally have become sources of river pollution. These sources of pollution have been divided into two categories: point sources (also known as fixed sources) and non-point sources (also known as non-fixed sources) (Sahoo et al., 2021; Sabater et al., 2022; Zakariah et al., 2022). The point sources of river pollution are the discharge of wastewater from industrial zones or sewage treatment plants. Discharge pipelines piped from industrial premises or sewerage treatment plants are easy to identify as sources of river pollution because they are permanently installed to channel wastewater effluent from locations that are typically located near riverbanks (Bai et al., 2021; Schliemann et al., 2021).

Due to the permanent position of the waste channel, the relevant parties will be more vigilant with their waste disposal in the river; the source from this sort of point source is easily monitored by the authorities. Despite this, certain operating sectors continue to pollute indiscriminately, regardless of the impact on river sustainability. A study by Mokarram et al. (2020) reported that one of the main contamination sources in the river water of the Kor River, Iran has originated from the nearby petrochemical industry. The effluent from industries that contain dangerous heavy metals such as cadmium (Cd) and arsenic (As) not only impairs the quality of local drinking water but also exceeds predetermined levels of such pollutants.

In another scenario, Goi (2020) found that manufacturing businesses, agro-based industries, sewage plants, pig pens, and wet markets are the top polluters of Malaysian river waterways. Non-point sources, on the other hand, are a type of river pollution that is difficult to identify due to the lack of permanent sources or channels and the spread-out features such as runoff from land use, for instance, deforestation, agriculture, animal husbandry, residential, business, trade, industry, oil spillage from road vehicles, and a variety of other activities, as well as the entry of pollutants that are easily navigated, carried by the wind, and eventually, end up and contaminate the river system (Šrajbek et al., 2022; Zhao et al., 2022; Intisar et al., 2022; Hou et al., 2022). Figure 1 displays sources of river pollution.

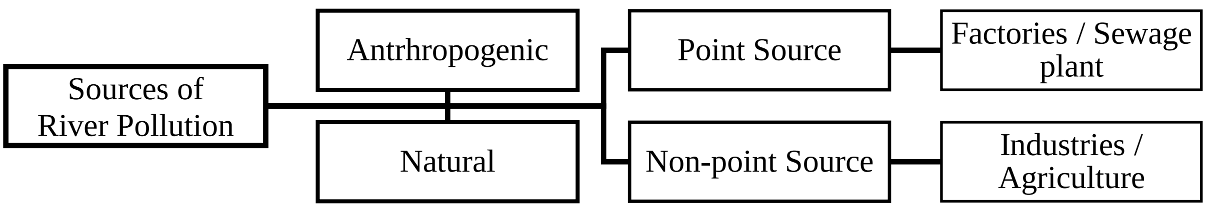

Figure 1: Sources of River Pollution

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JTHEM
EISSN: 0128-178X
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Most of the emerging pollutants come from non-point sources, including persistent organic pollutants (POPs) that currently pollute river ecosystems (Cui et al., 2022; Qu et al., 2021). The difficulty of determining the origin of pollutants from non-point sources causes them to be frequently discussed for monitoring and finding solutions to these pollutants. Further details on pollution through non-point sources as well as garbage and trash dumping, and disposal of various substances including sewage waste, toxic and chemical wastes, e.g., pesticides, and hydrocarbons will be discussed in the following sub-chapters. Figure 2 shows the types of river pollution worldwide.

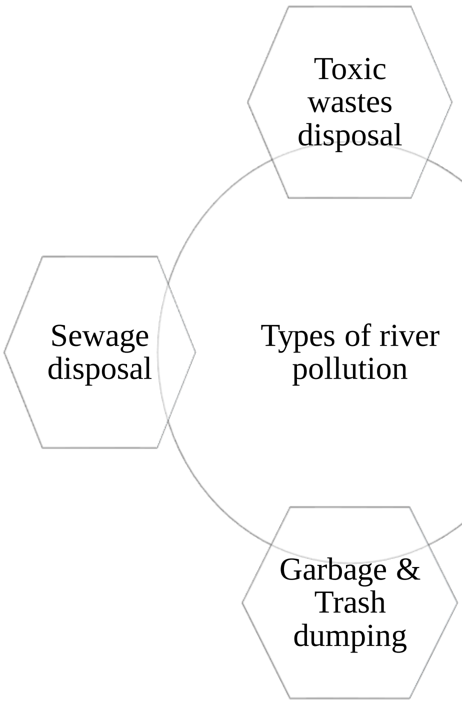

Figure 2: Sources of River Pollution Worldwide

Garbage Dumping

Some negligent people, who are unaware of the river's importance, let rivers become dumpsites for them. Plastic bottles or glasses, plastic bags, wooden furniture, polystyrene containers, food waste, electronic devices, and other garbage is thrown into the river are among the pollutants discovered in the rivers. Garbage that frequently floats and sinks in the river not only irritates the eyes but gives off a terrible odour. The river's quality, on the other hand, is degrading with the existence of the debris. Garbage dumping in the river is a common source of river pollution occurring globally including in China (Yao, 2021), Indonesia (Rumahorbo et al., 2021), Malaysia (Kamarudin et la., 2021), Thailand (Panyavaraporn et al., 2021), India (Khan et al., 2021a), Europe, and North America (van Calcar & van Emmerik, 2019).

Garbage dumped into the river will accumulate, cause a foul smell, and attract various pests to the riverside areas. Flies, cockroaches, and rats are likely to visit this filthy and polluted river, serving as a vector for diseases including diarrhoea, typhoid, and Leptospirosis, among others (Aboyitungiye & Gravitiani, 2021). Typhoid for example is a water-borne disease that is very contagious. The disease is caused by *Salmonella typhi* bacteria found in the stool or urine of

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patients which can also cause food poisoning. Poor sanitation management causes these bacteria to be in the river system and contaminate it. Kabir et al. (2022) reported typhoid cases were particularly common in settlements along peripheral rivers in Bangladesh due to river pollution. A similar situation was reported in Nigeria and India with the occurrence of various diseases including typhoid, schistosomiasis, cholera, diarrhoea, hepatitis, gastritis, and cancer, as the consequences of river pollution with innumerable contaminants and sources (Prajapati, 2022). (Adediran & Abdulsalam, 2021). Thailand has been identified as having an endemic case of leptospirosis.

In ten years, about 40,000 instances of human leptospirosis were discovered in several areas (Almanfaluthi et al., 2022; Phosri, 2022). Furthermore, the flotsam discarded into rivers may stagnate the water, allowing mosquitoes such as *Aedes aegypti*, which carry dengue fever, zika, chikungunya, and other viruses, to reproduce rapidly. Furthermore, putting the trash into the river system will not only pollute the river ecosystem but, at the same time increase the risk of flooding. During heavy rains, garbage will hinder the flow of water, causing river water to overflow (Aboyitungiye & Gravitiani, 2021). The maintenance and cleaning of the river from garbage pollution will be costly and time-consuming (Daniel, 2018). This is very detrimental to all parties, as the money should be used to upgrade other sectors, including education, public health, and national security.

Disposal of Sewage Waste

Furthermore, in some settlements, a small number of communities direct waste from their homes straight into the river without being properly treated. This is common in locations where there is a high population density and there is no well-managed sewage treatment system. The direct flow of sewage containing numerous dangerous bacteria into the river produces a significant drop in water quality, rendering the river water unfit for daily usage as well as domestic, industrial, and agricultural utilization. Sewage is known as the most common source of water microbiological pollution (Some et al., 2021). In detail, human and animal decontamination wastes contain harmful bacteria like *Escherichia coli*, Salmonella, nematode worms, and other microbes (Berendes et al., 2020). Given the fact that bacterial gastrointestinal diseases such as cholera, shigellosis, bloody diarrhoea, diarrhoea, and typhoid can spread to humans through water polluted with an infected person's faeces, the scenario of river water pollution due to direct sewage discharge into the river system cannot be taken lightly (Helard et al., 2019).

On account of overflowing home sewage or non-point sources of human and animal waste, faecal coliform bacteria may be found in the river water. Faecal coliform bacteria suggest sewage contamination of a stream along with the possible existence of additional harmful pathogen species (Ansari & Kumar, 2022). The sudden presence of these harmful microorganisms in the river will harm people's and animals' health and even endanger their lives. This sewage disposal is organic waste contamination that should not be taken lightly and needs to be addressed right away. Deguenon et al. (2019) and Salgado et al. (2018) in their study found that direct disposal of sewerage into the river located in Brazil decreased the quality of river water in terms of the amount of dissolved oxygen and other physicochemical parameters. On the other hand, sewage discarding escalates the eutrophication phenomenon in the river by adding excessive nutrients together with phosphorus (P) and nitrogen (N) from human and animal faeces (Kaiser & Lerch, 2022; Tiwari & Pal, 2022). Excess nutrients have

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JTHEM
EISSN: 0128-178X
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accelerated the growth of aquatic plants with imbalanced compositions, such as algae, including noxious algae, disrupting river ecosystems Glibert et al., 2018).

Toxic Waste Disposal
The influx of toxic waste into the river has exacerbated the river's pre-existing pollution from garbage and sewage. Water, sediment, and aquatic life have all been found to contain hazardous wastes in the river systems. Nonetheless, the manufacturing industrial, agricultural, and shipping industries are among the few that can be linked to the presence of these harmful toxic substances in river ecosystems. Heavy metals, hydrocarbons, and pesticides are some of thetoxic waste chemical substances found in river ecosystems (Refai et al., 2022; Khan et al., 2021b; Parween et al., 2021). The details of these toxic waste pollutants are discussed in the next sub-chapter.

Heavy Metals
Heavy metals are one of the primary pollutants in the river environments, anthropogenic and natural activities are two important sources of the presence of heavy metals in the river ecosystems (Zhao et al., 2018). Heavy metals such as mercury (Hg), lead (Pb), cadmium (Cd), and others have an adverse negative impact on the river ecosystem including aquatic resources. Heavy metals on the other hand are found to harm the nervous system, lung, brain, and kidneys if they enter the human and animal bodies (Guzzi et al., 2021). A study was carried out by Islam et al. (2022) to determine the types of heavy metals in the Tunggak River and Gebeng River on Peninsular Malaysia's East Coast. About ten different types of heavy metals were discovered in water samples collected from those sampling locations. However, only six heavy metals (viz. Co, Cd, Pb, Cu, Ni, and Mn) were detected with a concentration higher than Malaysian standards (Islam et al., 2022). Among the sources of heavy metals, pollution identified is industrial and domestic wastewater discharges that are not properly treated. In addition, runoff from deforestation activities also contributes to the presence of heavy metals in the rivers.

Hydrocarbons
Consequently, there are numerous cases of toxic waste disposal occurring all over the world. This is due to the perpetrators' careless attitude, which underestimates the river's importance to them. Hydrocarbons are one of the most frequently detected pollutants in river ecosystems. The decreased immune system, damage to vital organs such as the liver and kidneys, cancer-causing, and genetic damage are among the adverse effects that occur to humans and animals exposed to hydrocarbon contamination. Most worryingly, the persistent nature and ability to biomagnify along the food chain make this toxic substance one of the dreaded contaminants. A case of illegal dumping of hazardous toxic waste involving mostly hydrocarbons compounds has shocked Malaysia in early March 2019 where hazardous chemicals including methane, d-limonene, xylene, acrylonitrile, benzene, acrolein, ethylbenzene, toluene, and hydrogen chloride were identified in water samples from Kim Kim River, Pasir Gudang, Johor. The tragedy is that around 1,000 pupils who were close to the waste dump were affected by these harmful wastes. Shortness of breath, vomiting, coughing and severe throat irritation are some of the symptoms they suffer (Ibrahim et al., 2021).

Pesticides
The use of pesticides and herbicides in agricultural areas, domestic use, and landscape development also worsen the condition of the river with the flow of pesticides into the river. In

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addition, surface runoff from agricultural areas, especially during heavy rains directly into the river, also carries pesticide residues that will eventually pollute the river. Aquatic life, which is a source of food for humans, will be polluted. Toxins entering the river system in high concentrations will kill aquatic resources such as fish, crabs, shrimp, and more. Such events will disrupt the food chain and thus our ecosystem. Furthermore, the use of prohibited pesticides, such as those in the organochlorine group, raises serious concerns. These pesticides will build up in the fats of aquatic life like fish, shrimp, snails, and crabs. Because of the biomagnification property of these harmful substances, if humans consume contaminated aquatic life, the pesticide concentration in human body fat will be increased. A study by Perkins et al. (2021) reported that pesticide compounds like imidacloprid, fipronil, and fipronil metabolites, which are commonly used to eradicate parasites in pets, were discovered in river water samples taken from several English rivers.

Acid Rain

Acid rain is also categorised as one of the non-point sources of river pollution. This is because the content of pollutants that cause acid rain cannot be detected due to the long-distance movement features of pollutants from the source of their application. However, power plants and factories that release their waste into the air are the main sources of pollutants that produce acid rain. The release of gases such as nitrogen oxides (NO_2) and sulphur dioxide (SO_2) from factories and vehicles will combine with rainwater to form acid rain. At the same time, acid rain is also caused by the combustion of vehicle fuel. The exhaust from automobiles, trucks, and buses emits NO_2 and SO_2 into the atmosphere.

Consequently, these pollutants are spread by the wind and react with rainwater droplets to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3). Acid rain is a worldwide environmental problem apprehension. Acid rain will cause rivers to become more acidic and cause the destruction of aquatic life. The acidity of river water will have an impact on aquatic food sources such as algae and other aquatic plants. The food chain in the river ecology will be disrupted as a result of this situation (Mohajan, 2018). Acidic river water is not only unsuitable for aquatic habitats but also unsuitable for use by humans and animals for any activity (Han et al., 2019).

Conclusion

Overall, various human activities contribute to river pollution. However, for point source river pollution, the direct release of untreated wastewater from industries and sewage plants is one of the main causes of river pollution. This is due to a lack of responsibility to prevent river pollution. Irresponsible parties take simple, quick, and cost-effective steps toward wastewater management by simply dumping them directly into rivers without regard to the adverse effects on natural resources (Wang et al., 2018). In addition, the inefficiency of wastewater treatment applied by the industries involved resulted in still hazardous waste being discharged into the river even after the wastewater was treated.

This is where we can see the importance of the industry taking a smart step by making a small investment through monitoring and enhancing research and development (R&D) on their wastewater treatment before it is discharged into the river. The industry involved needs to choose the best wastewater treatment to treat their wastewater. This is to ensure that their treated wastewater does not adversely affect the river ecosystem (Agarwal & Singh, 2022). On the other side, the non-point source is considered one of the main causes of pollution in river ecosystems. This is because of its difficult nature to detect and control.

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EISSN: 0128-178X
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Pollutants enter the river environment from a variety of mediums including land, water, and air (Schweitzer & Noblet, 2018). On land, surface runoffs that occur during heavy rainfall are a major contributing factor to the entry of pollutants such as agricultural, livestock, and industrial wastes into rivers. In addition, the leaching process also drives toxic materials applied or dumped in the surrounding area to the river. Wind repulsion is also a cause that brings in toxic pollutants that are easily evaporated, such as pesticides into the river (Häder et al., 2020). Oil spills from leaking vehicle engines or vehicle maintenance workshops that occur on land will eventually end up in river areas through rain flushes. To preserve and conserve rivers in our country, we can take a variety of steps.

Improvements in chemical and garbage dumping management, which can leverage the country's most recent modern technology research results, are one of the actions that can be taken to prevent river pollution. The recycling of glass, paper, and plastic bottles is believed to help minimise pollution in our rivers (Hole & Hole, 2019). Furthermore, from as early as childhood, the attitude of enjoying the river should be cultivated. Using various platforms such as television, radio, the internet, and social media (e.g., Facebook, Instagram, Twitter, and YouTube channel several campaigns to love the river have been held. Various sorts of notice boards and advertisements were also displayed to instill in our culture the attitude of loving the river so that it might continue to thrive. For us to work together to preserve our rivers clean, we need awareness from all walks of life. It is intended that, as a civilization with a more developed mindset, the cleanliness of our waterways will reflect our attitude. A clean and attractive river can be a wonderful location to relax and unwind, and the surrounding community will undoubtedly benefit.

In general, this article has successfully gathered, identified, and described various causes and effects that lead to river pollution problems. On the other hand, it is hoped that this writing will contribute to various parties in educating the community about how important rivers and their resources are to all. In conclusion, to cope with all types of pollution and to guarantee the management of a basin's water resources as a component of the natural ecosystem and in connection to their socio-economic situation, good river management practices are essential involving all parties globally.

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