FLUORIDE

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Policy Recommendations for Mitigating the Impact of Fluoride Toxicity on Aquatic Life and its Influence on Domestic Tourism

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ABSTRACT

Purpose: Water pollution is a concern that harms aquatic ecosystems and has economic and social consequences. Over the years, industrial, agricultural, and municipal activities have contributed to the deterioration of water quality, raising concerns among researchers about its impact on society. The River Kabul in Pakistan faces pollution challenges, including Fluoride contamination. However, more is needed to know about how this affects tourism in the area. Therefore, this study aims to contribute to existing knowledge by examining the influence of contamination on tourism activities in the River Kabul region. Aquatic fluoride contamination is currently an issue with toxicological implications.

Methods: A mix method Approach was applied to gather information to know the water quality and its impact on local fishermen livelihood and tourism, before that water samples were collected to identify the level fluoride selective sampling techniques is outlined.The respondents were selected from tourist spots along the river Kabul for interviews.

Results: The study uncovered findings and outcomes. Firstly it revealed that water pollution in River Kabul had a effect on domestic tourism activities in Pakistan. Tourists were discouraged from participating in water related activities like swimming and boating due to the water containing high levels of fluoride.

Conclusions: The research findings have shown that the river is facing problems, with water pollution and high levels of fluoride. These issues are having an impact on tourism as the poor water quality, caused by pollutants like heavy metals organic matter and microbial contamination is leading to a decrease in the number of tourists visiting the region. This decline in tourism is causing losses for the area. Moreover the presence of pollution not affects tourists but also poses health risks to local residents making it even more discouraging for people to engage in tourism activities.

Key-words: Water Pollution, Fluoride Contamination, River Kabul, Domestic Tourism

INTRODUCTION

Background information on water pollution and fluoride

Water pollution is becoming a growing concern over the world. We have ample evidence of its impact on the environment and human health[1]. In Pakistan's Kabul River, the situation is even more severe due to fluoride, a mineral that occurs abundantly in that region. A study conducted in (2018) found that the Kabul River is heavily contaminated with fluoride, exceeding the limits set by the World Health Organization (WHO)[2]. Excessive fluoride levels in the water have been linked to health issues like dental and skeletal fluorosis[3].

Furthermore, it has been discovered that water contaminated with fluoride also risks tourism activities as it can affect tourists and their health[4]. Therefore, it is imperative to understand the extent of water pollution and how fluoride impacts tourism concerning the Kabul River. This understanding will help us develop strategies to address this problem adequately.

Fluoride and Aquatic Life

Fluoride contamination in water has been extensively studied around the world. There are ways in which fluoride finds its way into water[5]. One significant source of contamination is the presence of minerals containing fluorine in sediments and rocks. Pesticides and industrial waste also contribute significantly to levels in water. The harmful effects of fluoride on life and freshwater organisms are well documented. It has been observed that the availability of ions decreases as water hardness increases. Fish have been found to accumulate fluoride in their bones and flesh due to their attraction to calcium ions[6]. When humans consume fish contaminated with fluoride, it enters their bodies as well. While a small amount of fluoride prevents tooth decay, excessive amounts can cause fluorosis.High contamination can negatively impact the overall health of all living organisms[7]. Studies suggest that consuming fish as part of our diet is one of the leading contributors to fluorosis among humans[8].

When the concentration of ions in water increases, it severely impacts the health of fish and other aquatic organisms. The duration of exposure also plays a role in determining the occurrence and severity of toxicity[9]. Interestingly, higher levels of chloride and calcium ions can reduce the effects of fluoride on fish. Fluoride enters the fish body and Disrupts essential enzymes for their normal functioning. This interference poisons these enzymes, preventing them from carrying out their functions. As a result, critical metabolic processes like glycolysis are disturbed, which are vital for maintaining the well-being of fish living in freshwater environments[10]. In this review our main focus is to understand how fluoride toxicity affects the health condition of freshwater fish.

Toxicological Effects of Fluoride on Fish

Previous research has indicated that invertebrates and fish inhabiting freshwater, particularly adult salmon migrating upstream, tend to be more vulnerable to the effects of toxicity compared to those living in estuarine and saline environments[11]. Studies have demonstrated that even a fluoride concentration as low as 0.5 mg/l can produce toxic effects on the aquatic life dwelling in freshwater. This heightened risk of toxicity among organisms residing in freshwater, unlike their counterparts in saline water, can be attributed to the ionic content present in fresh water[12]. Concentrations of fluoride below 0.5 mg/l are generally considered safe. It is recommended to maintain levels below this threshold to protect freshwater animals from pollution[13].

The concentration level directly impacts its accumulation within the bodies of fish, thereby influencing their weight and length[14]. For instance, a study observed a decrease in growth over 90 days among sturgeon (which encompasses 27 fish species belonging to the *Acipenseridae* family) when exposed to concentrations ranging from 10 mg F/l to 60 mg F/l[15]. Another study on *Puntius ticto* fish species residing in Lake Nainital, Uttarakhand, India, demonstrated changes in fish length and weight corresponding with variations observed in aquatic fluoride concentration levels[16].

Fluoride acts as a metabolic inhibitor by affecting nutrient metabolizing enzymes[17].The liver of Heteropneustes fossilis showed changes in enzymes and histopathology when exposed to fluoride. In *Labeo rohita*, sublethal exposure to fluoride resulted in decreased protein levels in the liver, muscle, gills, and kidneys[18]. Similarly these organs also exhibited reduced glycoge & lipid content. Additionally histopathological changes were observed in the gills, kidneys and intestines of *Labeo rohita*. Researchers have also reported the impact of toxicity on the column of a freshwater fish called *Lata (Channa punctatus)*[19].

be toxic to our health. When fluoride levels are high there is an increase in its uptake by our system[23]. The primary source of entry into the body is through the

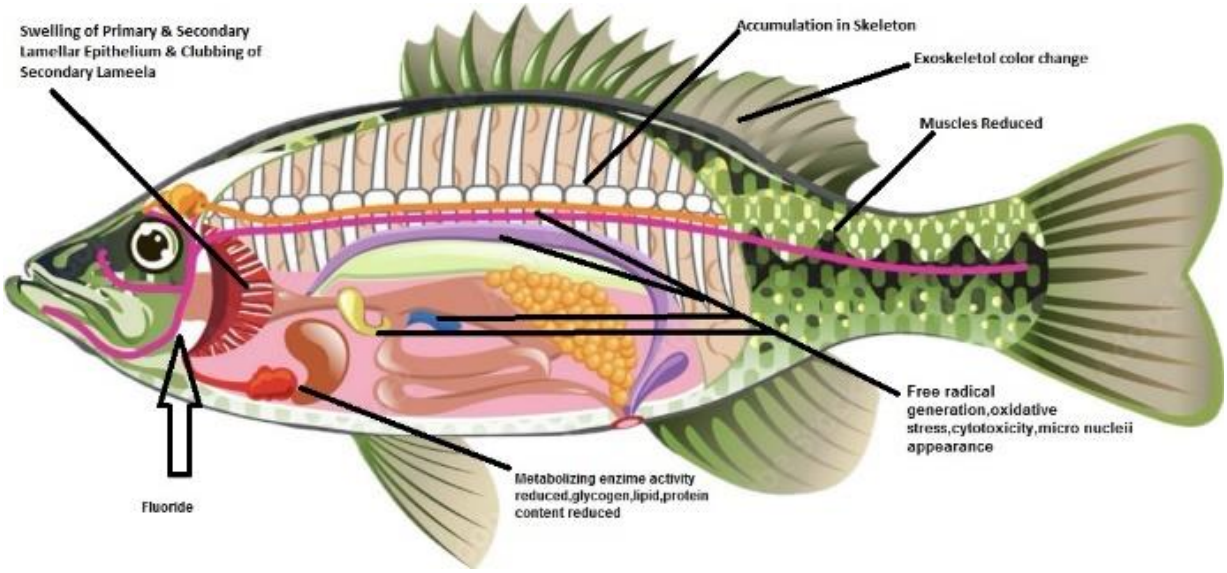


Fig-1: A sketch representing effects of Fluoride toxicity on Fresh water Fish: Source (Gosh,2019)

consumption of fish as part of our diet[25].

Genotoxic effects of toxicity on freshwater fish have been discovered through a study conducted on catfish. *Cyprinus carpio* displayed decreased weight gain and body growth as reduced food intake due to fluoride exposure[6]. Studies indicate that high concentrations of fluoride can lead to cytotoxicity[20]. Such concentrations may inhibit cell division. Impede growth while also inducing apoptosis. Fluoride toxicity is known to affect pathways involved in cell division and apoptosis[21]. Research suggests that fish exposed to fluoride experience swelling of the secondary epithelium in their gills. Additionally clubbing was observed at the tip of the epithelium, in fish exposed to fluoride[22].

Additionally the gills of fish exposed to fluoride showed signs of hypertrophy and hyperplasia. Research indicates that fluoride toxicity, in fish leads to alterations in gastrointestinal organs such as the stomach, liver, intestines and kidneys. A study conducted on *Channa punctatus* Fig-1 further demonstrate that fluoride triggers stress and has a detrimental impact on the liver of fish[6].

From Fish to Humans

It is widely recognized that fluoride has effects when in low concentrations in our bloodstream[23]. At these levels, the uptake of fluoride by our bones remains limited. The observed effects are beneficial. No cases of disease caused by a deficiency have been documented in humans[24]. However, it should be noted that higher concentrations of circulating fluoride can

When we consume fish contaminated with fluoride on a basis, our bodies cannot utilize this surplus, and it accumulates over time. Fortunately, the body does not readily absorb fluoride and Eliminates it through feces[6]. After ingestion, the fluoride concentration in plasma reaches its peak within 20 to 60 minutes. Gradually declines due to excretion through urine and uptake by calcified tissues[26]. Once inside the body at concentrations fluoride can have adverse effects on health and has been found to negatively impact cognitive development, in children[27].

Excessive exposure to fluoride in humans can lead to skeletal fluorosis and increased tooth decay, weakened and discolored teeth, and other related issues[28]. Studies indicate that fluoride can interfere with and harm enzymes in the body. When fluoride interacts with the metal ions found in enzymes, it disrupts their functioning. Affects overall physiological processes[29]. Moreover fluoride has been linked to causing calcium levels in the body[30]. Therefore it is important to be cautious about consuming fish, from water sources contaminated with fluoride to avoid health risks.fig-2 represents fluoride effects entering human body while containing fluoride contamination fish.

Tourism in Pakistan

People, from parts of the world travel to destinations for various reasons, such as business, leisure and seeking thrilling experiences. Some tourists are particularly drawn to places with cultures, customs

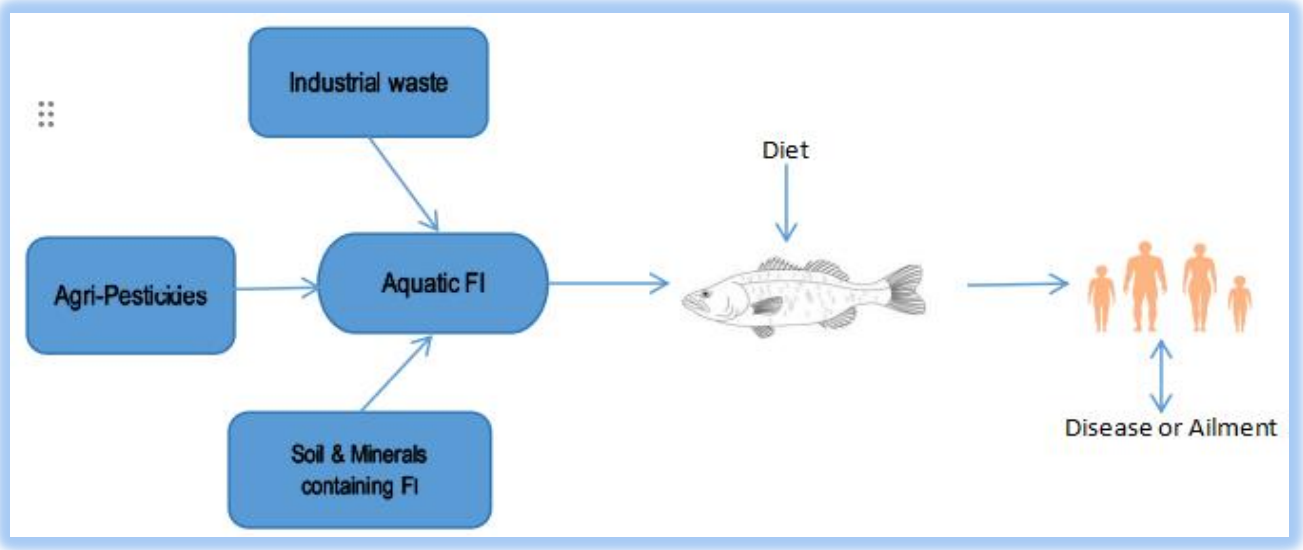


Fig-2: Fluoride from various sources to human body through fish diet

and traditions. They explore expressions, historical structures, majestic mountains, serene lakes, local languages, diverse climates and delicious regional cuisines. Pakistan stands out as one country that encompasses all these attractive elements and offers breathing landscapes and natural beauty. It boasts tourism assets owing to its archaeological heritage, cultural diversity, stunning beaches captivating deserts picturesque views all around including glaciers and mountain ranges. These features provide a plethora of attractions for both travelers and domestic visitors[31] Tourism in Pakistan can be classified into four types; religious tourism focusing on sites; archaeological and historical tourism centered around ancient relics; ecotourism emphasizing nature conservation; and adventure tourism catering to thrill seekers[32].

The Travel and Tourism Competitiveness Index (TTCI) regularly publishes a report evaluating countries potential for tourism. According to the 2017 TTCI report findings Pakistan ranked 124th among 136 countries examined in terms of its tourist appeal[33]. In 2016 the contribution of travel and tourism activities to Pakistan's economy amounted to USD 7.6 billion or 2.7% of its GDP as reported by WTTC (World Travel & Tourism Council) in 2017[34].

Furthermore the government of Pakistan has set goals aimed at boosting the share of tourism, in their nations GDP.In Pakistan the tourism sector has gained prominence as it recognizes the role it plays in creating job-opportunities. The Tourism Development Corporation of Pakistan operates (PTDC) under the Ministry of Tourism,faces challenges in regions due to inadequate facilities and infrastructure. Unfortunately while there has been a focus, on growth less attention has been given to preserving the environment, which is a crucial aspect of long term sustainability[35].

Tourism and water environment

In the tourism sector improving the comfort of tourists during their travels involves making changes, to the environment. However it's important to note that tourism activities can also have an impact on the environment especially when it comes to water resources[36]. When the water environment becomes polluted aquatic organisms are the first to be affected followed by the land surrounding the watershed, which in turn affects surface organisms growth. If developmental actions are not taken of tourist destinations can result in depleted tourism resources and hinder further tourism growth[37].

Achieving an sustainable tourism industry requires finding a balance between preservation, material utilization from natural resources and waste management generated during development processes. Human activities associated with tourism also play a role in benefits as well as generating pollutants. In areas where water environments are marketed for tourism purposes it is essential to consider both human influences, on water pollution capacity and provision of tourism resources[38].

The water environment follows rules. Various human tourism activities can also affect it (usually in a negative way). Similarly changes, in the water environment can also respond to tourism activities. For instance if the water environment improves it will attract tourists. Boost the economic benefits of tourism. Conversely if the water environment deteriorates tourists may reconsider visiting the area making it challenging for tourism to thrive and causing local living conditions to worsen[39].

Importance of domestic tourism activities

One important factor of engaging in tourism is its impact, on a country's economic growth and development. When domestic tourists spend their money on accommodation, transportation, food and local products it generates revenue for businesses and Creates job opportunities for the population[40]. Moreover domestic tourism plays a role in advancing the economy by encouraging the establishment of infrastructure like hotels, restaurants and transportation facilities. This development attracts tourists. Contributes to the overall growth of the tourism industry[41].

Additionally domestic tourism plays a role in preserving heritage and traditions as tourists partake in activities such, as visiting historical sites participating in local festivals and exploring indigenous cuisines[42]. By appreciating and promoting diversity through these activities domestic tourism helps to maintain and strengthen national identity[43]. Therefore it is clear that supporting and promoting tourism activities can bring economic, social and cultural benefits to a country.

Impact of fluoride on tourism activities

Apart, from the consequences to human health the presence of fluoride in water bodies can have an impact on tourism. Tourists are attracted to destinations for their beauty and recreational opportunities. If the water is contaminated with fluoride it can jeopardize these activities sustainability[44]. Research indicates that fluoride pollutants can harm ecosystems leading to a decline in water quality and biodiversity[45]. This could negatively affect tourism activities like swimming boating and fishing since visitors might be hesitant to engage in these activities in waters. Additionally concerns about the health risks associated with exposure may discourage tourists from visiting affected areas[46]. Therefore policymakers and environmental authorities must address the issue of pollution in water bodies to ensure long term viability, for tourism and the economic growth it brings.

Area profile;

The study area lies within Pakistans Khyber Pakhtunkhwa (KPK) Province (Fig. 3). Geographically speaking, Charsadda district covers an area of 996 km2 (243753 acres). Charsadda tehsil is bordered by Tangi in the north, Mardan district in the east, Nowshera and Peshawar districts in the south, and Shabqadar in the west. The geographical coordinates of Charsadda range between 71° 53' to 71° 28' East longitudes and 34° 03' to 34° 38' North latitudes.

The tourist spots in Charsadda

Sardaryab stands out. Situated on the banks of Kabul River in Charsadda District Sardaryab is located 20 kilometers (12 mi) northeast of Peshawar. It attracts tourists with its beauty. Offers activities, like enjoying fresh fish meals and boat riding.

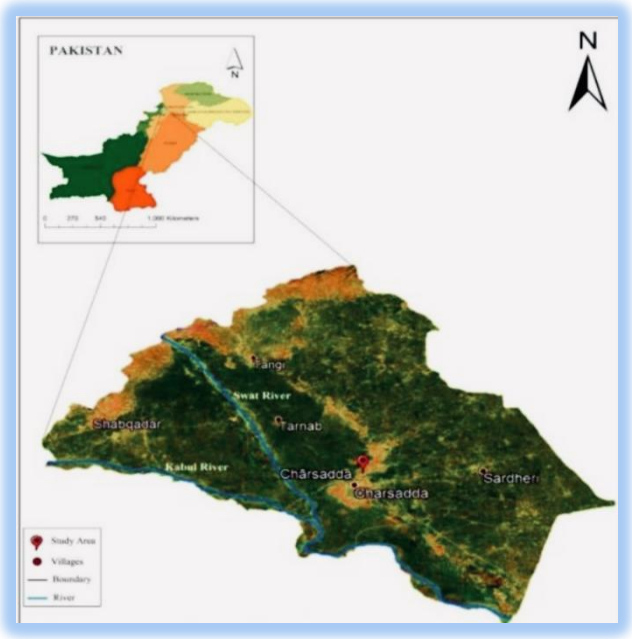


Fig-3: Map of Charsadda-River Kabul

Source:Google earth

MATERIAL AND METHODS

Project area

The Kabul River, stretching for 700 kilometers (430 miles), originates in the Range of the Hindu Kush mountains in Afghanistan. It eventually merges with the Indus River near Attock, Pakistan, making it a significant tributary of the Indus[47]. Along its course, the Kabul River passes through cities including Kabul, Surobi, and Jalalabad in Afghanistan before crossing into Khyber Pakhtunkhwa in Pakistan. Some notable tributaries joining the Kabul River include the Logar, Panjshir, Alingar, Kunar, Bara, and Swat Rivers.

However, it remains a trickle for parts of the year; during summer, its flow increases due to melted snow from the Hindu Kush Range. Of all its tributaries, Kunar River is the one which originates as Mastuj River from Chiantar glacier in Brughil valley in Chitral (Pakistan).After flowing into Afghanistan and being joined by the Bashgal River from the Nurestan region, it meets with the Kabul River near Jalalabad, where they merge to form what is known as the Kabul River.

In Pakistan, the Warsak Dam is situated in the Peshawar Valley, 20 km northwest of Peshawar. The untreated municipal and industrial waste from Peshawar,Mardan, Nowshera, and Charsadda districts is being discharged into drains that eventually flow into the Kabul River. We have assessed the water quality at three spots at Charsadda where Kabul River flows.these spots include Sardaryab,Naguman and Khyali.

In order to know F level in River Kabul and designated tourist spots we analyzed surface water samples from rivers and drains.The results showed in table 1 that Fluoride level in Kabul river exceed than maximum-level.

Table-1: Analysis of Major Ions in Kabul River water

Parameter	Unit	WHO-Standard	Mean	Median	Min	Max
Fluoride (F)	mg/l	1.5	0.50	0.39	0.20	**1.59**
Electrical conductivity	µS/cm	1,000	780.1	670.0	296.0	**2,667.0**
TDS	mg/l	1,000	399.4	351.0	147.0	**1,333.0**
Turbidity	NTU	5	2.3	1.2	0.4	**19.0**
SO_4	mg/l	250				**>400**
Cl	mg/l	250	65.4	42.0	30.0	**297.0**
NO_3	mg/l	50	6.5	3.0	0.0	50.0
Ca	mg/l	250	122.2	120.0	59.0	249.0
Mg	mg/l	250	32.7	24.0	24.0	133.0
Fe	mg/l	2	0.1	0.2	0.0	0.4

While Electrical conductivity,TDS,Turbidity showed significant increase in River Kabul and the surrounding areas.

Effects on Fish Life in River Kabul

The Kabul River used to be well known for its fish. There has been a decrease in fish population since 1992. A study conducted in the 1990s reported that there were originally 156 native freshwater species in the Kabul River System. In Pakistan there are 45 fish species, with seven species being economically important[48]. Out of these 45 species have been found in the river and about 35 of them are commonly found throughout its length[49] .

However recent studies have shown that now 10 species remain. Among these,two species are abundant two are sufficient in numbers and six species are considered rare. The main reasons for this decline can be attributed to the discharge of industrial waste into the river and the construction of dams. The fish population may further decline if there is a decrease, in water volume or an increase in pollution. This decline can be attributed to pollution levels . Through conversations with residents living along the river it has been discovered that several unauthorized and highly undesirable fishing methods are being used.

These methods include current, explosives and insecticides such as *Malathion, Thiodan, Cymag, Endo Sulfan, Cypermethrin and Sanogas* . Field studies have also shown that overfishing and industrial discharge have led to a decline in fish population. In the Sardaryab area various huts are visible where fish is offered for sale[50].

Table -2: Percent effect on common fish species at River Kabul

Fish Species	Municipal	Industrial	Agriculture	Status
Shair Mahi	30 %	55%	15%	Rare
Sangara	30%	55%	15%	Rare
Rohu	35%	50%	15%	Rare
Silver Carp	45%	50%	5%	Rare
Mar Mahi	40%	40%	20%	Rare
Torkay	25%	55%	20%	Rare
Mali-	20%	30%	40%	**Abundant**
Solay-	25%	40%	35%	**Abundant**
Swati Fish-	30%	50%	20%	Adequate
Mashair	30%	50%	20%	Adequate

Decrement of River Kabul Fish in Local Market

The survey conducted revealed changes in the species found in the Kabul River (*Mashair, Shair Mahi*

Mali, Mar Mahi, Sangara, Swati and *Solay*). However among these species Sangara ,Mar Mahi and Solay are not popular in the market. The local markets mostly offer Rahu Silver and China Kab which come from ponds and dams in Punjab .

In the survey we have identified three factors that have an impact, on fish population.These factors include Municipal waste,industrial discharges, agriculture pesticides. Currently we observe that two species (Mali and Solay) are abundant,but in decline. while two species are considered adequate and six species are classified as rare according to Table 2.

Both municipal and industrial pollution have effects on all fish species. On average Sangara(*Mystus seenghala*) and Shair Mahi (*Clupiosoma Nazir*) experience an impact of 85% each. The contribution of agriculture in terms of agro-chemicals (pesticides) is relatively low. The effect on Silver (*Hypophthalmich thys molitrix*), Mashair (*Tor putitora*),and Shair Mahi (*Clupiosoma Nazir*) is 5%, 20% and 15% respectively . while on Torkay (*Labeo dyocheilus*),Swati(*Schizothorax plagiostomus*) and Sangara (*Mystus seenghala*) it is 20%,20% and 15%; whereas Rahu (*Labeo rohita*) experiences a 15% impact. Overall two species (Mali and Solay) are still relatively abundant but showing signs of decline.

Due to contamination the fish belong to Kabul river saw a rapid decline in local market. There are two species that are considered adequate. On the hand there are six species that have been identified as rare as shown in fig 4 in local market .

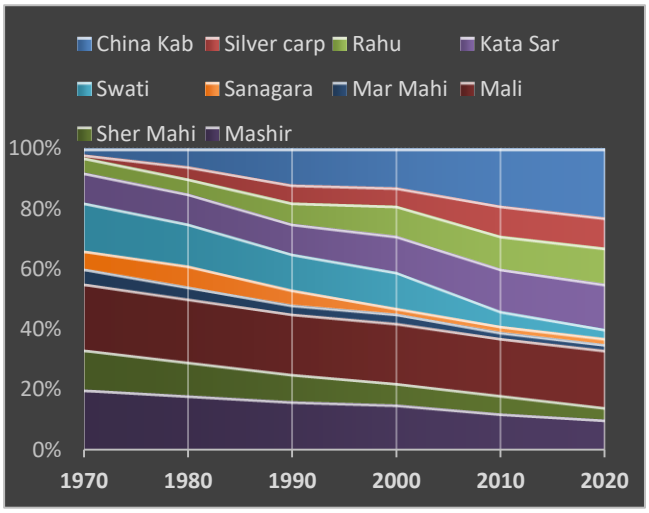


Fig-4:Decrement in Kabul's River Fish Population in Local Market

Respondents Selection and Interview

To gather information on the impacted fishermen we utilized selective sampling techniques as outlined in Table 3. We selected respondents, from tourist spots along the river Kabul. Our approach involved identifying and interviewing fishermen resulting in a total of 45 interviews with fishermen and 55 interviews with laborers. Additionally we conducted interviews with huts and hotels owners that offer fish. In total we interviewed 100 individuals, including 40 from Sardayab 20 from Naguman and another 20 from Khyali. The tourist spots along the River Kabul.

To complement our research an extensive literature review was conducted to gather insights into pollution, in the Kabul River. Furthermore to understand fishing techniques and trends we employed appraisal (PRA) methods. These methods allowed us to collect data utilizing a timeline based PRA technique.

Additionally, conversations took place with 20 owners of fishing huts and 45 tourists on the fish serving spots . A total of 165 individuals were interviewed, including fishermen, shop owners people from fisheries department and tourists regarding decrease in fish population and quality of water.

Table-3: Respondents interviews at different spots

Tourist Spots	Fishermen	Labour	Shop owner/Huts	Local Tourists
Sardaryab	20	25	10	25
Naguman	15	20	05	10
Khyali	10	10	05	10

Effects on Fishing Community and inflow of Domestic Tourist

This significant decline has had impacts on the fishing community living near or along the banks of the Kabul River. In the past fishing was an occupation for 80% of people living by the river in the year 1970.

However by year 2010 this percentage had dropped to 20%. Many fishermen from the nineties now work as laborers, for hut owners who sell fish along the banks of Kabul River (Fig.5) while others have switched occupations entirely.The fish population may further decline if there is a decrease, in water volume or an increase in pollution. On the the Sardaryab fishing site on bank of Kabul river one can find huts that offer cooked or fried fish. It is believed that the

fish served along the riverbank comes from the Kabul River. However a survey conducted in 2010 revealed that 30% of the fish actually comes from Kabul River while the remaining 70% comes from parts of Pakistan like Turbilla Dam and various fish farms in Punjab.A recent survey conducted in the area showed that 10% of the fish catch came from Kabul River while 90% was sourced from other areas of Pakistan.

This polluted area acts as an obstacle to fish breeding and blocks routes for fishes, between Indus and Swat River. If water quantity continues to decrease it will reduce dilution capacity. Increase pollution levels.That's why this significant economic activity might vanish or the contribution, from the Kabul River, to fishing could further decline, impacting businesses related to fish.

Fig-5: Huts offering fried fish at Sardayab on the bank of River Kabul

Based on our survey we found that there were individuals who used to make a living, as fishermen along the riverbank. Surprisingly the majority of them (around 85%) have now abandoned this profession. Around thirty percent of these fishermen have shifted their focus to activities while another 20% have taken up additional work alongside fishing. Lastly 35% of them have completely given up fishing as their livelihood.

In Figure 6 you can observe the drift in the occupations of these fishermen over time. Prior to 1970 fishing was their source of income, sustenance and way of life. However survey reveals that there has been a decrease in fish catches by around 10-15 kilograms.

Furthermore it's important to note that this significant change within the fishing community has also been influenced by factors such as industrial pollution, Municipal and agriculture waste.

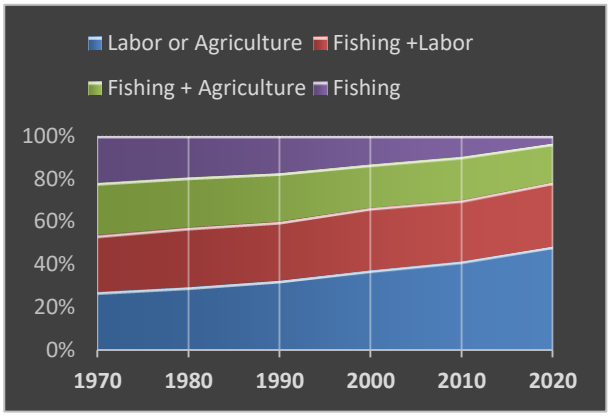


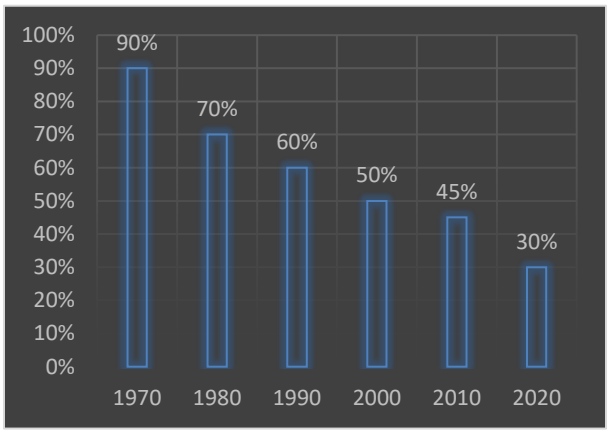
Fig-6: A Drift From Fishing to Other Occupations Over Time

Based on our survey it was found that all the fishermen we interviewed are burdened with debt and are compelled to work at hotels for a period to repay these debts. As a result underprivileged fishermen have been pushed out of the fishing industry. The management of the fish department is also not playing a role, in safeguarding this profession. According to the survey fishermen have highlighted that the use of shocks illegal methods of catching fish and explosives in water are diminishing fish breeding areas leading to a decline, over the years.

If this situation continues unchanged River Kabul will experience a loss in its productivity. Because of fluoride contamination and water pollution many tourists now don't visit to these tourist spots along the banks of Kabul river which brings huge economic effects on the lives of these fishermen.

Due to decrease in fish population and water contamination, it also effect tourists inflow to these fishing spots as shown in table 4 the tourists flow to the fishing huts drops drastically after every few years because they couldn't get the famous local Kabul river fishes which in return effects the livelihood of fishermen and businessmen, due to decrease in tourist inflow it impacts the overall economic conditions.

Table-4:Decrease in tourist flow over the time



RESULTS AND PROPOSED STRATEGIES

Mitigation and Management Strategies

Addressing the issue of water pollution and its impact on domestic tourism activities is crucial, as evidenced by the case study of River Kabul in Pakistan. To protect our valuable natural resources and support the tourism industry, it is vital to implement effective mitigation and management strategies. One important approach highlighted in the research is promoting sustainable practices for managing wastewater. This includes adopting appropriate technologies for treating wastewater, ensuring its proper disposal or reuse and minimizing its negative effects on the environment and tourism[51]. Additionally, enforcing relevant legislation and regulations related to pollution control plays a significant role in mitigating water pollution and preserving tourist sites. Public awareness campaigns and educational programs are also essential in promoting responsible behavior and sustainable tourism practices[52]. By combining these strategies with robust monitoring systems , we can effectively mitigate water pollution while safeguarding domestic tourism activities and ensuring sustainable development of Pakistan's tourism industry.

Government policies and regulations to control water pollution

Government policies and regulations play a vital role in managing water pollution. One way the government can achieve this is by enforcing laws that regulate industrial discharges into rivers and requiring companies to treat their wastewater before releasing it into water bodies. Additionally, imposing strict penalties for non compliance with these regulations can act as a deterrent and encourage businesses to adopt more environmentally friendly practices. Moreover, government agencies can establish monitoring systems to regularly evaluate water quality and identify potential sources of pollution, enabling timely interventions when needed. Lastly organizing public awareness campaigns can educate communities on preventing water pollution and promoting responsible use of water resources. Overall, these policies and regulations are effective tools for addressing the challenges posed by water pollution while safeguarding the sustainability of domestic tourism activities (as seen in the River Kabul case study).

Water treatment methods to reduce fluoride contamination

To address the problem of contamination, in water sources several methods have been developed for water treatment. One used approach is the activated alumina process, which utilizes alumina as an adsorbent to remove ions from water. This method has been proven effective in reducing concentration to levels suitable for drinking water[53]. Another method that has gained attention is osmosis, where a semipermeable membrane selectively removes ions from water[54]. Additionally coagulation and precipitation techniques involving the addition of lime or alum have shown results in reducing levels[55]. It's important to consider factors like cost, efficiency and compatibility with existing infrastructure when choosing a water treatment method[56] . By implementing these methods we can effectively mitigate the issue of contamination in water sources. Ensure the safety of domestic tourism activities in regions such, as the River Kabul.

Promoting sustainable tourism practices to minimize pollution and fluoride effects

To mitigate the impacts of water pollution and fluoride, on tourism it's crucial to promote sustainable tourism practices. Sustainable tourism focuses on minimizing the social effects of tourism activities while ensuring the long term sustainability of destinations[57]. By adopting tourism practices like promoting Eco accommodations implementing effective waste management systems and educating tourists about the importance of preserving natural resources we can minimize pollution and fluoride effects[58]. Certification programs such as Green Globe and Earth Check can be tools in evaluating and promoting practices in the tourism industry[59] .

Additionally collaboration between government bodies, local communities and stakeholders in the tourism sector is vital for establishing and enforcing regulations that support tourism[60] . Through the integration of tourism practices in the Kabul River region of Pakistan we can reduce the impacts of pollution and fluoride, on domestic tourism activities ensuring a flourishing and healthy tourism sector.

FINDINGS AND DISCUSSION

Findings and results of the study

The study uncovered findings and outcomes. Firstly it revealed that water pollution, in River Kabul had a effect on domestic tourism activities in Pakistan. Tourists were discouraged from participating in water related activities like swimming and boating due to the water containing high levels of fluoride. This discovery aligns with research highlighting the impact of water pollution on tourism [61]. Additionally the study found that the presence of fluoride in the water had effects on tourists health raising concerns about long term consequences. These findings support claims made by researchers who have investigated the effects of excessive fluoride exposure on human health[62]. Overall this study emphasizes the need for measures to address water pollution and tackle the issue of excessive fluoride levels, in River Kabul to safeguard domestic tourism activities.

Discussion on the implications and recommendations for future actions

The results of this research, on the impact of water pollution and fluoride on tourism activities in the River Kabul Pakistan carry implications for actions. To begin with it is clear that water pollution and fluoride contamination have an effect on the attractiveness and popularity of tourism sites along the river. The presence of pollutants and high levels of fluoride not pose health risks to visitors. Also harm the visual appeal of the location resulting in a decrease in visitor numbers.

Furthermore this study emphasizes the need for measures to address water pollution and control contamination in the River Kabul. The government and relevant authorities should prioritize implementing and enforcing regulations to prevent industrial waste discharge and agricultural runoff into the river. Additionally raising awareness among communities and tourists about the consequences of water pollution while promoting tourism practices can contribute to sustainable tourism development, in that area.

CONCLUSIONS

In conclusion this research article aims to examine how water pollution and fluoride impact domestic tourism activities with a focus on River Kabul, in Pakistan. The research findings have shown that the river is facing problems, with water pollution and high levels of fluoride. These issues are having an impact on tourism as the poor water quality, caused by pollutants like heavy metals organic matter and microbial contamination is leading to a decrease in the number of tourists visiting the region. This decline in tourism is causing losses for the area. Moreover the presence of pollution not affects tourists but also poses health risks to local residents making it even more discouraging for people to engage in tourism activities. The study emphasizes the need for measures to control water pollution and improve water treatment methods to safeguard the tourism industry. In addition to this it is crucial for policymakers and stakeholders to prioritize development practices and environmental conservation efforts in order to reduce water pollution effects on domestic tourism activities, in the River Kabul region.

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