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PLASTIC POLLUTION- A CHALLENGE FOR OPERATION OF CANAL IRRIGATION AND DRAINAGE NETWORK IN PUNJAB PAKISTAN

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by

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Abstract

Plastics pollution is one of the biggest challenges in the operation of irrigation system. It causes clogging of irrigation channels and damage to the infrastructure. Plastic debris can accumulate in canals resulting in blockages, that disrupt water flow and reduce the efficiency of the channel. Plastic pollution in canals can contaminate water sources, affecting the quality of water used for irrigation and potentially harming crops and aquatic life. Plastics pollution in irrigation networks can lead to increased operational and maintenance costs and can cause damage to the environment and biodiversity. Irrigation system of Pakistan is one of the largest gravity flow irrigation networks in the world. Major components of the irrigation system include rivers, dams, barrages, headworks, main canals, branch canals, distributary canals, outlets, escapes, drains, water courses, bridges, syphons and other hydraulic structures. A province wise survey in this context has been conducted, sites visited and discussions with field staff responsible for operation and maintenance have been made to assess the impacts of plastic pollution on the operation and maintenance of the irrigation and drainage systems in the Punjab. Stakeholders at site have also been consulted. An assessment of physical damage and challenges has been made and resulting financial implications estimated. Major sources of plastic pollution identified in irrigation canals include agricultural plastics, poor waste management in catchments, heavy winds, rainfall and street runoff from urban centers. Microplastics can enter the irrigation system from waste treatment plants, agricultural runoff, and industries. A similar situation has been observed for the drainage network. Plastic pollution causes clogging, stoppage of flow, which increases the

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retention period of polluted water, hinders the flow velocity and increase the deep percolation of contaminated water resulting in the groundwater contamination. It has been found that plastic pollution starts right from the catchments in mountain regions where tourism coupled with lack of awareness and responsibility among the community and tourists cause the plastics to travel and entre the flowing water towards streams, rivers, dams, canals, and downwards, even up to the sea. It has been estimated that about 8-12% of annual desilting budget (amounting to Rs. 50 to 60 M) is consumed annually in fighting the hazard of plastic pollution for smooth operation of irrigation networks in Punjab province. Recommendations for smooth operation and maintenance of canal and drainage systems include holistic regulations and strict implementation, waste management practices, use of biodegradable plastics, awareness campaigns and community education.

Key words: Plastic pollution, irrigation, drainage, Punjab, Pakistan

Background

Pakistan lies in southern Asia, bordered to the east by India, the west by Iran and Afghanistan and to the north by China. The total area is 803,940 km^2. It consists of four provinces viz; Punjab, Sindh, Baluchistan, Khyber Pakhtunkhwa; one capital territory; and two autonomous states of Azad Jammu and Kashmir and Gilgit Baltistan. Terrain consists of the flat-lying Indus Plain in the east, mountains of the Himalaya, Karakoram and Hindukush ranges in the north, hill regions (up to 4761 m) in the north-west, and the upland Baluchistan plateau in the west. Elevation ranges are extreme, from K2 (8611 m) to the Indian Ocean (0 m) **(BGS, 2001)**. The Indus Basin Irrigation System (IBIS) of Pakistan as shown in **Figure-1**, is one of the largest gravity-flow irrigation networks in the world. Major part of IBIS lies in the Punjab province.

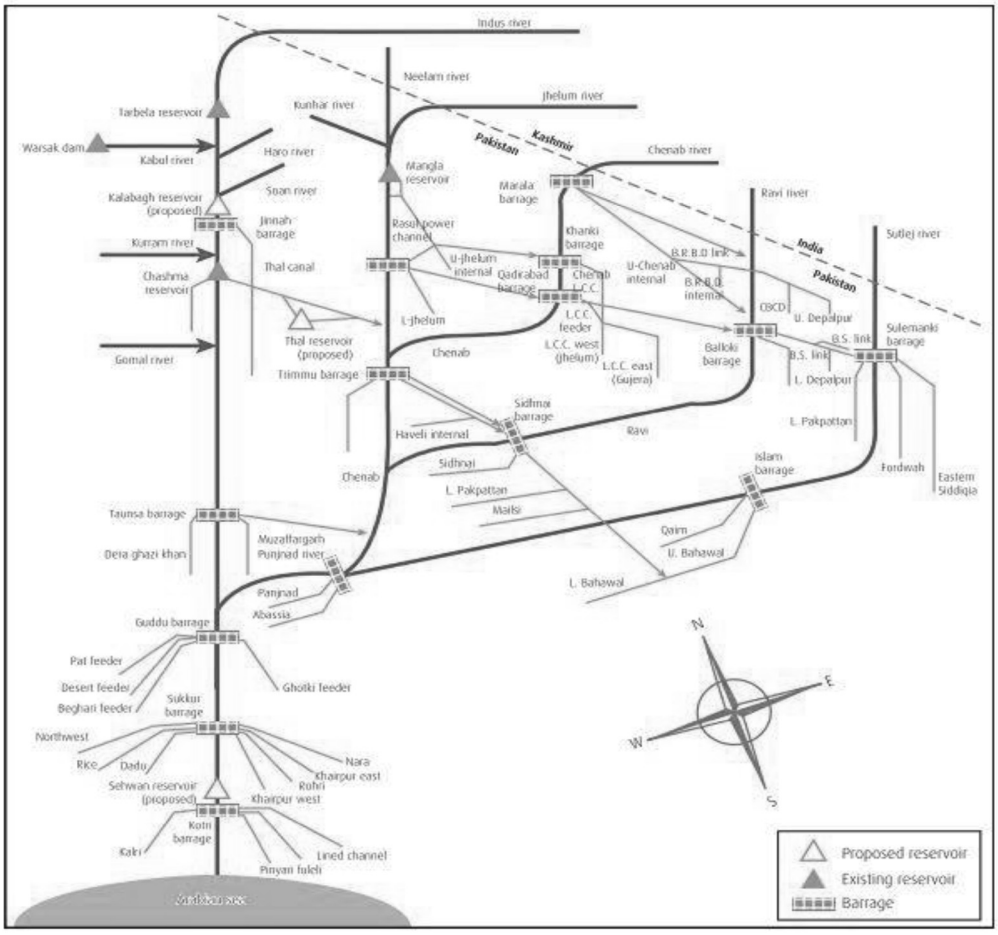


Figure-1: Schematic diagram of Indus River Basin (IRB)

Millions of tons of plastic waste are being generated constantly and entering into our environment from industrial units, agricultural areas and dwellings **(Shen et al., 2021)**. Most of the daily use products are composed of one or the other form of a plastics which affects about 267 species **(Isangedighi et al., 2018)**. Plastic industry boomed during and after the second World War. Plastics have entered our life and now every second item in our daily life is made of some sort of plastic **(Khurshid, 2019)**. Plastic pollution is posing adverse impacts on human health, livelihood, environment, tourism and economy in a broader sense. Plastics are typically synthetic polymers of high molecular weight that consist of many organic and inorganic compounds and mostly derived from petro-chemicals **(Gopal et al., 2014; Tibbetts, 2015).** Worldwide, plastics are part of products including plastic bags, packaging and household objects. The convenience and benefit of plastic has come at a cost.

In Pakistan, plastic waste is a major environmental and public health problem particularly in the urban areas **(Javed et al., 1998)**. As per **Modern Diplomacy (2020)**, about 8 million metric tons of plastic are produced globally out of which only 9 per cent are recycled. Most of the waste finds in ways to rivers, canals, drains and oceans through runoff, as water moves from source to sea **(Nikiema et al., 2020)**. Cost of overall environmental pollution in Pakistan is 8.9 per cent of GDP **(World Bank, 2019)** wherein plastic accounts for 6% of total waste in Pakistan. Plastics are popular because many are heat resistant, light weight and long lived, but these properties make plastic waste particularly problematic. Plastics take 20-1000 years to degrade and hence pose a disposal challenge for controlling the plastic wastage and cause many adverse impacts **(Proshad et al., 2018).** For example, some estimates suggest that 50 years are needed for biodegradation of Styrofoam cups, and 450 years for plastic water bottles.

Plastic industry in Pakistan has experienced steady growth, driven by the expanding manufacturing sector and increasing consumer demand for plastic products due to low cost and durability**.** In 2024, Pakistan exported plastics worth approximately **US$ 527.9 million**, marking an increase from **US$ 492 million** in 2023. Pakistan generates approximately **3.3 million tons of plastic waste annually**, with only about **4%** being recycled. This low recycling rate underscores the need for enhanced waste management practices and the adoption of circular economy principles.

Gopal et al., 2014; Sigler, 2014 reflected that plastic bag waste contributes to blockage of drains and gutters and are a threat to aquatic life when they find their way to water bodies. (**Delilah L 2011)** concluded that plastics are extremely diverse in terms of chemical composition, properties and possible applications, and are widely distributed in the society and the environment. (**Laist 1997)** and **(Wabnitz and Nichols 2010)** inferred that due to ingestion or entanglement in plastic debris, over 270 species, including turtles, fish, seabirds, and mammals, have experienced impaired movement, starvation, or death. **(Kookana et al., 2017)** have reported that plastic wastes can be very dangerous, and a source of contamination for surface and groundwater. Plastic pollution is a rapidly growing problem as the demand for use of plastics is increasing. It has been estimated that under the business-as-usual scenario by 2050 about 12 billion metric tons of plastic waste in the natural systems will be a big challenge **(Nikiema et al., 2020)**. **Talpur, 2018** reported that plastic production at global level has increased from 2 million-tones (MT) to 380 MT since 1967. Plastic pollution decreases the value of ecosystem services and potentially causing negative health implications for all types of lives **(Vegter et al 2017)**. As said by **Blackwell**

2012 "Water is something every living organism on this planet cannot live without. If this resource is so precious that life cannot exist without it, we shouldn't be contaminating it"**.** As per an estimate about 8.3-billion-ton plastic has been produced to-date (**Roland Geyer et al 2017**). If current position and waste management trends continue, roughly 12 billion tons of plastic waste will be in landfills or the natural environment by 2050 **(Zakir-Hassan et al., 2018)**. According estimates by **(World Bank, 2021)** about 334 million metric tons of solid waste are produced annually in South Asia which becomes third largest contributor towards the plastic waste. As such, the Indus River System has become one of the top five polluted rivers around the globe.

The increased use and production of plastic in developing countries is a severe concern, as the improvement of waste management may not be able to keep up with the production of plastic waste. Over the last ten years we have produced more plastics than during whole of the last century. The major land-based sources are illegal dumping and inadequate waste management. (**Kibria 2017)**. As highlighted by **(Hafeez, 2018**) plastic pollution has severe impacts on marine life, mainly due to lack of awareness and non-implementation of existing rules/laws. Mindset of the common people needs to be changed as thoughtless usage and neglectful disposal of plastic waste have become a major environmental and health hazard. In Bangladesh, sewerage lines and drains have been choked severely with carelessly discarded millions of plastic bags **(Molla, 2021)**. Per capita consumption of plastic in Pakistan is 5.5 kg per year, compared with Bangladesh about eight kg, 135 kg in Singapore, 100 kg in USA and 70 kg in UK **(Molla, 2021)**. Plastic bags are favored for a number of their desirable properties such as low weight, durability and for a number of their other end uses like convenience in packing food stuff and other multifarious items besides virtually no cost to the end-user i.e customer **(Habib, 2021)**.

Present consumption of plastics in Pakistan is around 5.5 kg per capita per year. This consumption is very likely to increase due to certain encouraging factors like urbanization, modern lifestyles, spreading of vast shopping malls on modern lines, increased use of bottled water, introduction of new drinks and lack of awareness **(Qaiser, 2018)**. Plastic industry in Pakistan is growing at an annual average rate of 15 per cent and per capita consumption has shown an upward trend during the last 15 years (**WB**, 2019).

As per a survey conducted by the government of Pakistan in 2004, more than 8000 plastic bags manufacturing units were working in Pakistan and about 55 billion plastic bags were being used in Pakistan which is

approximately 1 bag per person per day. (**WB**, 2019) has established that complete phasing out of the use of non-biodegradable plastics is one of the key steps towards a clean and green Pakistan. Sustainable development goals 12. 13 and 14 also talk about plastic pollution and its control.

As reported by **Habib, 2021** used plastic bags and other items are notorious for choking sewers, open drainage system, spoiling sanitation and creating an overall unaesthetic view of environment. The practice of burning them on street sides at dumpsites produces dioxins and furans, which are excessively and extensively being inhaled by human beings. Due to their extreme toxicity to human system, they are responsible for producing serious diseases such as cancer. Under universally accepted international requirement, dioxins and furans are required to be absolutely absent in air. In Pakistan, the plastic pollution has appeared now in the form of a menace to the environment in the form of oozing out of awfully dirty water on streets making stinking pools as good breeding grounds for a number of vectors of diseases like flies and mosquitos. These vectors spread diseases like cholera, typhoid, diarrhea, awful odor, contamination of drinking water thus further spreading these diseases and even hepatitis A.

Filed Surveys and Investigations

Water bodies like streams, rivers, canals, drains, dams, barrages, lakes, reservoirs, oceans are the ultimate destination of most of the plastics irrespective of where we dispose them off. Natural carriers like wind and rainfall transport these waste materials from one place to other and some travelling for many hundred kilometers. These plastics materials travel in water channels and finally reach either the irrigation fields or the ocean if not trapped/removed on the way. Rainfall, glaciers, groundwater reservoir are the major sources of water in Pakistan. Almost 90 per cent of the agriculture produce is dependent upon irrigation water supplies which ultimately ensure food-security in the country. The irrigated agriculture of Pakistan mainly depends on IBIS. The annual flow of Indus River is $1.76x10^9$ mega litters (MLs) out of which $1.27x10^8$ MLs is diverted into canal systems through a network of barrages and headworks. About 80 per cent flow of the Indus River is generated during monsoon period i.e. from June-September, which necessitates the effective water management for sustainability of irrigated agriculture **(Cheema et al., 2014).** In Pakistan irrigation water flows through network of rivers and barrages to canals and agricultural fields while effluents (agricultural, domestic, industrial) are carried via reverse flow through drainage network from fields to rivers and other water bodies mostly without proper treatment. Water flow system (WFS) in Pakistan is shown in **Figure-2.**

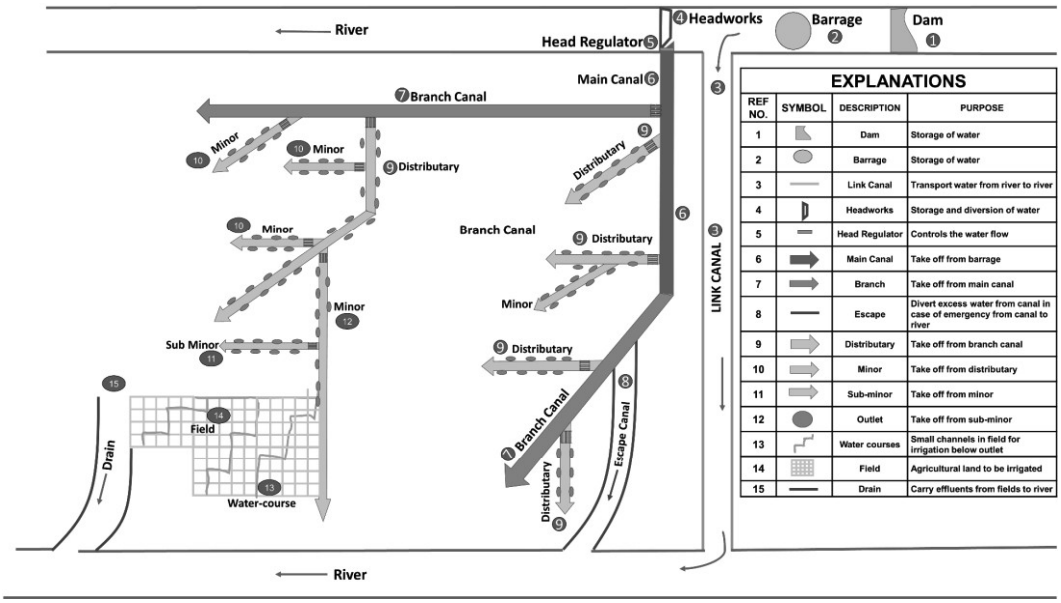


Figure-2: Various components of Indus Basin Irrigation System in Pakistan: Source (Zakir-Hassan, 2023)

Different hydraulic structures have been surveyed in irrigation zones in the Punjab province to observe the physical hurdles in flow system by collection of necessary information/data, observation of on-ground situation and review of records of concerned operational staff. Physical, environmental, health risks, social, and financial implications of the plastic waste flowing along with the irrigation water right from the catchment areas to irrigation fields have been observed and evaluated. Onsite visits and survey along with operational staff have been made to assess the adverse impacts on the operation and maintenance of irrigation infrastructure. Site conditions at Rawal Dam which is a source of drinking water for Rawalpindi and Islamabad (the federal capital) are shown in **Figure-3**.

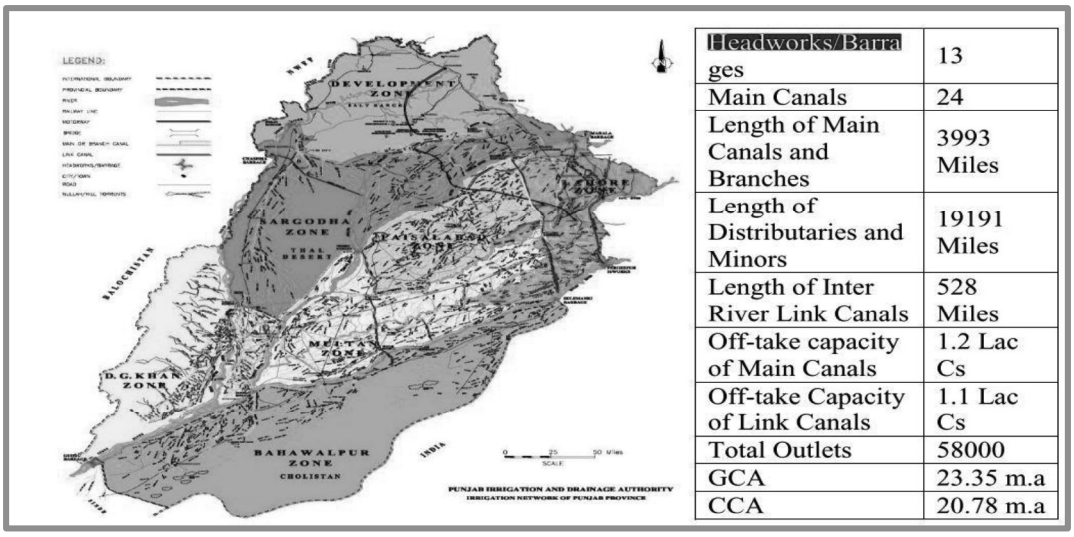


Figure-3: Plastic accumulation in Rawal Dam Rawalpindi, Pakistan

Irrigation Channels

Different control structures have been constructed over the rivers, canals and drains where these plastics are entangled and pose many physical, environmental and financial constraints to successful operation and maintenance of the WFS. The Punjab irrigation system along with major components, as shown in **Figure 4**, serves about 10.84 million hectares of cultureable lands at existing average cropping intensity of 130 per cent or even more at some places.

The river supplies are distributed to agricultural fields through a network of main canals, branch canals, distributaries, minors, outlets, and watercourse. Punjab irrigation network is badly affected due to plastic accumulations at different points which are creating multidimensional challenges/threats for the smooth operation of the system. Different canals in the province have been visited and it has been found that plastic accumulation causes reduction in channel capacity as well in flow velocity. The plastic rubbish that has fallen on the roads/cities, gets washed away into the nearby water reservoirs, canals, and drains, leading to their choking, blockage of flow, overflowing, breaching of banks, degradation of water quality, and growth of aquatic plants/weeds which serves as shelters for the breeding of mosquitoes and other harmful vectors insects. For example, the pictures in **Figure 5** are of Lower Bari Doab Canal (LBDC) showing accumulation of plastic wastes. This canal is passing through urban area and people carelessly throw the trash in the water and on the banks of canal from where it comes into water.



Headworks/Barrages	13
Main Canals	24
Length of Main Canals and Branches	3993 Miles
Length of Distributaries and Minors	19191 Miles
Length of Inter River Link Canals	528 Miles
Off-take capacity of Main Canals	1.2 Lac Cs
Off-take Capacity of Link Canals	1.1 Lac Cs
Total Outlets	58000
GCA	23.35 m.a
CCA	20.78 m.a

Figure-4: Punjab irrigation network and major features



Figure-5: Plastic accumulation in Lower Bari Doab Canal (LBDC) Punjab, Pakistan

Drainage Network

Punjab canal irrigation network is supported by a parallel drainage network, which carries domestic, industrial and agricultural effluent towards the rivers and other natural streams. **(UNEP, 2016)** have highlighted that micro plastics pose adverse impacts on human health through food chain. Mechanical abrasion of vehicles tyers on roads also produces micro plastics which then are washed away by rainfall and flow into natural and municipal drainage networks and a part of its leaches down to groundwater reservoir. **(Zakir-Hassan et al., 2017)** during a study along Ravi River near the Lahore city in Pakistan found that drainage effluents are putting an adverse impact on the quality of groundwater reservoir. Plastics entre into our drainage system from industries, vehicular emissions, and general waste from parks/households. Debris, plastic accumulation result in clogging, blockage and hindrance in flow of the drains which causes increased retention time for wastewater causing more deep percolation resulting in degradation of lands, deterioration of ground water quality and increased O&M cost of the drainage system. Overtopping during rainy season and breaches also occur due to plastic accumulation. Drainage network of Punjab Province with main features is shown in **Figure-6**. Plastic accumulation in drains of Sargodha and Lahore Zones is shown in **Figures-7 and 8.**



Sr. No.	Name of Irrigation Zone	Number of Drains	Total Length of Drains (Km)
1	Lahore	277	2108
2	Faisalabad	222	2420
3	Multan	44	1351
4	Sargodha	383	3087
5	DG Khan	61	677
6	Bahalwalpur	20	340

Figure-6: Drainage network of Punjab Province, Pakistan (Zakir-Hassan et al., 2017)



Figure-7: Plastic accumulation in drains in Sargodha Irrigation Zone



Figure-8: Plastic accumulation in drains in Lahore Irrigation Zone

Blockage of drainage network causes the increase in the retention-time of polluted water which contains domestic, agricultural and industrial effluents. Hazardous water when stays in the drainage network for a longer period, enhances the deep percolation of polluted water which resultantly pollutes the land and groundwater and the subsurface ecosystems. Similarly, plastics dumped in landfill when degrade due to weathering effects, toxic chemical produced leach down when there is rainfall and pollute the groundwater. **(Chu et al., 2019)** modelled the transport of micro plastics through porous media, how this moves into groundwater through advection and diffusion processes in the canal system.

Accumulation of stagnant plastic debris is a major hurdle in the velocity of flow in the drain increasing retention period of effluents in the channel. This provides an extra opportunity to the effluents to seep down and ultimately contaminate the groundwater. Results have indicated that pollution in Hudiara drain is posing adverse impacts on groundwater which has been further aggravated by clogging of drain due to plastic wastes.

Hydropower Projects and threats by Plastics

Hydropower plays a vital role in meeting the energy requirements in Pakistan. Hydropower stations have been installed at suitable sites on many canals in Punjab to meet local energy demands. Plastic accumulation is a big challenge being faced in hydropower units resulting in the choking and chances of damage to machinery/system. A similar situation was observed in the precious asset of nation, which is Renala Hydropower Station, a unique hydropower station in the world. Sir Ganga Ram (1851–1927), a

leading philanthropist of his time, established Renala Hydropower Station in 1925, which was Pakistan's (British Indiat's) first hydropower station. Renala Khurd Hydropower Plant (RKHPP) is a small, low-head, run-of-the-river hydroelectric generation station with a 1.1 megawatts (1,500hp) capacity on the Lower Bari Doab Canal which provides power to about 50 houses (a small village) **(Wikipedia, 2020).** Plastic accumulation in the feeding channel of Sir Ganga Ram Hydropower station is shown in **Figure-9**. This pollution is creating hindrance in flow patterns, choking of low channels and serious threat for damage to machinery. It consumes a handsome share from operation and maintenance funds in addition to environmental, social and health impacts. Estimates have revealed that about 5-10 per cent of O&M funds are being spent annually to handle such pollution.



Figure-9: Plastic accumulation in the feeding channel of Sir Ganga Ram Hydropower station Renala, Punjab, Pakistan-growth of vegetation due to plastic accumulation

Hydraulic Structures and plastics

Other hydraulic structures of irrigation network like bridges, culverts, syphons, cross drainage works, headworks etc. are being affected badly by plastics floating in water channels. This causes blockage when stuck in diversion and other structures and sometimes causes damage to the structure, overtopping and disturbance in water distribution. Plastic accumulation at Ravi syphon near Lahore, is shown in **Figure-10.**



Figure-10: Plastic accumulation at Ravi syphon near Lahore, Punjab, Pakistan

Outlets-Agricultural Fields

Outlet is the last structure after which canal water runs through the water courses and the irrigators use it for irrigation of their fields as per a pre-agreed scheduling locally called “warabandi”. Plastic bags/bottles and other debris flowing through the irrigation network ultimately reach the outlet which is very narrow structure and is clogged easily by such floating waste material. Such stoppage of water causes overtopping of outlets and warabandi is disturbed and entitled farmers are deprived of their right of water on their turn. Some plastics floating along the water and crossing all hurdles/structures ultimately reach the agricultural field with irrigation water and remain there for rest of their life. When plastic are dumped in lands, it interacts with water and forms hazardous chemicals which cause land and water degradation besides creating physical hindrance in on-farm agronomic practices like ploughing, levelling, growing, irrigation, harvesting, etc., and cause a significant reduction in crop yields as well. When these chemicals seep underground, they degrade the groundwater quality.

Financial Implications of Plastic Pollution

As reported by **(Monroe, 2013)**, the city of Oakland spends about US$8.3 M, Chula Vista spends $1.7 M and Central Valley community of Merced spends $1.3 M per year on street sweeping and maintaining storm drains. As per 2019-20 budget estimates, Punjab Irrigation Department (PID) spent annually about Rs 2000 M (US$ 12.15 M) on maintenance and operation of canal irrigation network in the province **(https://irrigation.punjab.gov.pk/)**. This includes about 30 per cent (Rs 600 M) being spent on desilting and

cleanliness of canals and drains. It is very hard to segregate the costs required to remove only the plastic debris and related waste materials from the canal and drainage systems. Site surveys and inspections have been made jointly with field formations of PID, wherein it has been revealed and established that approximately 5-10 per cent of desilting funds (about Rs 30-60 M) are consumed in fighting the hazard of plastic pollution for smooth operation of irrigation network. However, this does not include the costs related to waste management and recycling, etc.

Discussions

As regards policies and regulatory frameworks these, no doubt, are imperative tools for mitigating the hazard of environmental degradation by plastic wastes. The irresponsible attitude of the community towards excessive use and improper disposal in a big challenge which adversely impacts the natural systems and environment. Effluents emerging from our cities, recreational spots, industrial areas, commercial units and even from agricultural fields contain plastic waste including microplastics. Some scattered and interim efforts have been made in Pakistan to combat this menace like; Government of Sindh province imposed a ban on the production, sale, purchase and use of black polyethylene bags from 26 August, 1994; The Punjab Environmental Protection Department imposed ban on black polyethylene bags from 5 June, 1995; the Baluchistan Government promulgated an ordinance on 19 February, 2001, titled: “the Baluchistan Prohibition on use and sale of polythene bags Ordinance, 2001”. Similarly, there is a Prime Minister of Pakistan’s directive to impose a complete ban on use of polyethylene bags issued vide PM’s office on February 22, 1997 **(Habib, 2021)**. But no holistic and comprehensive law has been promulgated to control production, transportations, use, recycle or reuse of plastics in the country.

The manufacturers of plastic bags oppose the ban on plastic bags, arguing that, employment of thousands of persons depends upon such cottage industries, which manufacture polyethylene bags **(The News, 2018)**. The ban will render many people jobless. They opine that in absence of polyethylene bags, if paper bags are to be used then it will involve cutting of more trees, which is also not advisable. They argue that, the issue is basically the collection of the solid waste. If the waste is collected by the municipal agencies regularly then there would be no polyethylene bags in the dustbins. Consequently, bags will not get airborne, to create nuisance.

Punjab province of Pakistan is home to about 60% of plastic processing units. Although bans have been imposed on single use plastics in 2018-2019 in Lahore and Islamabad but their implementation in letter and spirit

remains questionable **(Pathare, 2020)**. Many countries in the world have duly banned the use of plastic bags like Bangladesh, France and Rwanda. Learning from these examples, Pakistan has issued a Statutory Regulatory Order (SRO) to ban the plastic bags in Federal Capital Islamabad and other cities including Lahore and Hunza. However, at present Pakistan lacks in policy framework in the use of plastic bags **(Gul, 2020)**.

The mindset of the people needs to be changed, which is more important than the enforcement of any law. Success of any law/rule is largely linked with the awareness, understanding and response of the community. Due to financial constraints people are not ready to spend more on environmental considerations; for example, use of very thin plastic bags is common practice which are not re-useable. Lack of coordination among the producers, users and regulators is another challenge. Management of waste generated through plastic usage is an expensive and laborious business with very low profit margins. Therefore, it is necessary to reduce, remove, and recycle (3-Rs) the plastics before it enters the water systems. Different policies exist at national and provincial level like national climate change policy, national water policy, national sanitation policy, Punjab water policy, Punjab drinking water policy, and Punjab agriculture policy; but there is not at all, or inadequate provision for control and mitigation of this hazard in these documents. Only black plastic shopping bags have been banned in some provinces time and again, but it could not be materialized in letter and spirit. There is urgent need to interlink these policies horizontally as well as vertically in an integrated and comprehensive mode to address this issue. The problem actually lies with the municipalities as well, as they do not have the proper system to collect, sort, treat different types of waste. Everything goes to the landfill and we see plastic bags and other debris in open plots, nullahs, stormwater drains etc., causing urban flooding at times due to choked drains and sewer lines.

Conclusions and Recommended strategies

This study revealed that plastic waste is causing problems of environmental degradation and is becoming a growing challenge for smooth operation of canal irrigation network. Freshwater biodiversity, and groundwater are its major victims which ultimately pose adverse impacts on life. Major impacts of plastics on the smooth operation of canals and other structures of irrigation system in Punjab province of Pakistan have been identified as clogging and blockage, frequent breaches, hindrance in smooth flow of water, increasing sedimentation/silt deposition, choking of outlets, disturbance in cultivation/field operations, disturbance of water sharing among the stakeholders resulting in adverse impacts on farm-incomes and

food production, bad smell and environmental degradation, aquatic growth which provides shelters for breeding of mosquitoes and other harmful vectors insects causing risks on human health. Problems being posed on the drainage network have resulted due to more retention-time for wastewater resulting in deep percolation, degradation of lands, reducing agricultural productivity, adverse impacts on food security, deterioration/ degradation of groundwater quality, overflowing especially during rainy seasons, reduction in channel capacity, growth of aquatic plants/weeds-barrier in flow path causing reduction in flow velocity. Major drivers for wide spread of such type of pollution have been identified as lack of awareness, lack of will and writ, social response/commitment, holistic regulatory policy, shortage of financial resources, technology-transfer challenges, lack of coordination among the producers and consumers of plastic products, lack of capacity of institutions, etc. Soil fertility is affected due to plastic waste materials which reach ultimately to fields either by water or wind forces, as these form part of manure remaining in the soil for years without natural ruining. Further to above, now Covid-19 pandemic has further exacerbated the situation by adding masks, sanitizers and vaccination wastes to the system.

There are several sources of plastic accumulation at such places which travel from the watersheds under wind and water flows forces. It was observed that sources include tourist visits, local inhabitants, waste generated from agricultural and commercial activities, and plastic debris/wastes flowing with water from urban localities. Dams/barrages have tourist places where people visit very frequently for their picnic parties and enjoyment. They carry along with them, a lot of plastic bottles/plastic packing's/wrappers of food items/drinks which are not properly disposed off and are thrown away which ultimately accumulate and make their route to the water bodies. Different structures including Rawal Dam, Balloki Headwoeks, Trimmu Barrage, Islam Headworks have been visited for site inspections. It was observed that being a source of drinking water; impact on human health in addition to loss of aquatic life, reduction in storage capacity, financial burden, adverse/ugly environment and bad impression for tourism are some of the consequences of plastic accumulation. Accumulation of plastics/debris results in extra labor and machinery for the normal performance of hydropower stations. This leads to a remarkable increase in annual maintenance cost.

Plastics are useful materials and have attained a major role in our daily life. However, very thin, cheap plastics are not re-useable; therefore, are turned into waste. Their waste can be converted into fabrication of useful items of

daily use. Strategies for control of plastic can be distinguished and implemented according to type of plastic waste generated, financial resources, available knowledge and technology, and other factors like disposal sites availability, market demands etc. Different strategies can be designed and implemented at all stages of the life cycle of plastics for mitigation and taking remedial measures to avoid harmful impacts of plastic wastes.

Holistic and comprehensive regulatory policy framework with a sustainable strategy is required- involving regional and global cooperation- for technical aspects of plastics recycling, reuse and conversion. Awareness campaigns like “stop using plastics if you cannot reuse/recycle” must be launched massively to the grassroots level including the academic curricula for educating the people especially the youth and women about the plastic pollution and its impacts on our environment. Coordination amongst the stakeholders at all levels, social responsibility, commitment, ownership, capacity building, resource mobilization, public-private partnership, innovative research, non-traditional technology transfer, incentives for different actors in the manufacturing, supply, use and disposal of plastics are the imperative steps to combat this threat. Best practices/models in management and use of plastics need to be upscaled and replicated widely to fight against the plastic pollution. Alternate materials for packaging and other purposes needs to be sought to reduce dependence on plastics. As the waste management business is a low-profit activity, public sector and global community needs to be made aware and sensitized about the pollution of our ecosystems. Special site-specific measures for both surface and groundwater resources, land, oceans, lakes, dams, barrages, rivers, drains and canals etc. Remedial measures to capture plastic items at source, their use and disposal need to be developed and implemented. Certain plastic products which are not reusable or not biodegradable must be banned and the people whose livelihood is based upon such business may be provided alternate opportunities and incentives. The piecemeal policies/acts need to made comprehensive and user oriented after due consultation with all stakeholders. Plastic bags are banned in different province of Pakistan, but without proper arrangements of livelihood for the families associated with this business. The orders by the government which are issued without taking the end users on board, are very difficult to be implemented on ground. A multitude of tinny businesses are linked with plastics. Plastic waste can be a source of energy, many byproducts of daily use if we collect, handle and dispose it properly. End of life waste management and plastic-free policies for plastics can reduce the adverse impacts. For our water bodies like rivers, lakes, canals, drains, dams,

barrages are vulnerable to plastic pollution and we need to protect these at every step while water flows from source to sea. For this purpose, collaborative concrete steps are required to be taken by stakeholders from public, private, civil society, and regional levels. To tackle this impending issue, we need to think globally and act locally.

Note:

The results/findings presented in the paper are of the authors and do not reflect the point of view of any organization/department.

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