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WASTEWATER MANAGEMENT AT WAPDA HYDROPOWER PROJECTS

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ABSTRACT

Water & Power Development Authority (WAPDA) is the major entity in Hydropower development arena of Pakistan. It is performing key actor role to provide financially viable, socially acceptable and environmentally sustainable energy to national grid. Every development project as its aftermath is bound to modify the surrounding ecosystems. As hydropower projects are implemented on lotic water regimes, they ultimately change the pre-project water quality scenarios. One of the pivotal intruders is generation of wastewater during project implementation sprees. Wastewater management is a wholesome issue at national level, as more than 5 MAF annually is being generated and hardly 1% is treated. On the contrary WAPDA is giving its best, to protect the environment from undesirable pollutants. That is why, sustainable, mitigatory strives have been inculcated in the environmental management plans of T4th Hydropower Project (HPP). Neelum-Jhelum HPP, Dasu HPP and Keyal HPP are to manage the wastewater at sites in such a way that its ultimate footprints are reduced to bare minimum. Various wastewater management measures include; construction site stormwater control, batching plant wastewater management, taking stock of wastewater from labor camps, residences, offices and tunnels. Better management of quarry and dumping sites also go many a mile to avoid contamination of water bodies with silt and mud etc. Better wastewater management at under-construction water projects is also mitigating the impacts on downstream riparians and biota, leading to overall sustainability in the vicinity. Wapda Environment Cell (WEC) is supervising, coordinating and stewarding these strives at sites to enhance the environmental resilience of WAPDA projects.

INTRODUCTION

Water & Power Development Authority (WAPDA) is playing a key actor role in development and management of twin lifeline resources for the economy of Pakistan i.e. water and hydel energy. From its very inception in 1958 as torch bearer of this task WAPDA inculcated the concept of responsible and wholesome development in the country. It is pioneer organization that started to tread upon the path of environmentally sound and socially acceptable project implementation with the help of International Funding Agencies in late eighties. This task has got further impetus with the rapid

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population growth, deforestation, environmental degradation, depleting ground and surface water resources. As a result, the consideration of environmental sustainability became a norm rather than a rarity during implementation of WAPDA projects. To do the needful, WAPDA is playing a proactive role, by doing Environmental Impact Assessments and adopting ensuing environmental and social development plans at WAPDA projects. Ghazi Barotha Hydropower Project was the prime example in the chain of such projects. The moving spirit and driving force behind positive outcomes of this Project were ingraining of international good practices and sustainability norms; particularly taking stock of environmental and social ramifications of the project and their mitigation in befitting manner. Same model was emulated in WAPDA projects in the pipeline with enhanced and stringent considerations. During the lifecycle of a project all phases have their environmental and social footprints, predominantly in project vicinity. However, the construction phase of project has more footprints than other phases. Of particular importance are the impacts on health, safety and environment oriented parameters, after resettlement issues. One of the ultimate outcomes of hydropower project construction activity is generation of wastewater. The origin of wastewater may be from many point and non-point sources. Various factors contribute towards the nature of wastewater i.e. type of construction technology applied, size and gravity of project, awareness among stakeholders about wastewater management and kinds of raw materials used during project construction.

WAPDA at minuscule level is doing its bit to take stock of wastewater management. The gravity of wastewater mismanagement at national level required to be checked and minuscule success stories can pave a way to follow at national level.

In Environment Management Plan (EMP) of HPP scores of key performance indicators (KPIs) are chalked out to monitor and manage at every stage of project planning. These KPIs are monitored on regular basis to note that they are within national permissible limits. If these are above than a pre-project established baseline of wastewater generating point and non-points sources then mitigation measures are adopted to bring them within National Environmental Quality Standards (NEQS). During project construction continued monitoring is carried out not only to ascertain additional wastewater generation because of project implementation but also to adopt measures to manage wastewater on sustainable basis.

METHODOLOGY

The main impact upon surface water quality during the construction arise from increased sediment load, suspended solids and turbidity caused during the site preparation and earth moving, wastewater from construction worker camps and construction site offices. Accidental spillage of chemicals, fuel, and oils alongwith batching plant and tunnel oriented wastewater may also add to water pollution.

In case of clearance of vegetation in reservoir area the water quality may be impacted. The methodology adopted to manage the wastewater generated through different sources includes three phases / steps. As a first phase WAPDA ensures to collect details of water quality (before project implementation) of river upstream of proposed dam site, at dam site and at number of locations downstream. These are usually taken at different times of the year to establish a baseline.

The parameters or key environmental indicators (KEIs) measured to establish baseline usually include; Total Dissolved Solids, conductivity, BOD, pH, Turbidity, Temperature, etc. A wastewater quality measurement program is chalked out for project implementation stage. During the second phase, the environmental footprints of various project construction oriented activities generating wastewater are taken care of, through regular monitoring and in case of being more than national and international quality standards. Mitigatory strives are adopted.

The comparison of data collected during baseline studies and data collected during implementation stage, render it possible to record the changes and adopt the appropriate measures, in case of environmental degradation.

In the third phase: Post project changes in area of influence are monitored. The most important footprints of this phase include, monitoring and management of wastewater generated at point and non-point sources downstream of dam sites in regulated water supply regimes, particularly, in lean periods.

The potential sources of wastewater generation during project implementation increase manifold and so does the gravity and severity of issue. The wastewater generated from construction worker's camps and offices is predominantly of organic nature. While wastewater from tunnels, construction site run-off and wastewater from batching plants is treated under sediment and TDS oriented category. The third type is spillages of chemicals, fuels, and oils, which can be earmarked as wastewater with chemical and hazardous materials.

Different methodologies are applied for all three types of wastewaters. For predominantly organic wastewater, treatment plants are provided. For sediment oriented wastewater; Two-phase flow of wastewater in attached rectangular sedimentation tanks / settling ponds is ensured. The baffle is provided at appropriate position to ensure maximum settling of sediments. The most important part of these strives is the regular and timely cleaning of sediment / settling tanks and proper disposal of sludge. To avoid its re-introduction into downstream river flows.

Finally, to avoid chemical contamination of wastewater from spillage; fuels, oils and chemicals are stored and used at cemented platforms and bunds are constructed around stores. Emergency preparedness plans are chalked, equipment are arranged to deal accidental spillages.

As pre-emptive measure, best practice procedures for minimizing all kinds of contaminants and pollutants are adopted.

During operational phase of HPP, downstream environmental flows are ensured for dilution in impacted reaches of river.

3. Results and Discussion

3.1 Ghazi Barotha Hydropower Project and Wastewater Management

Ghazi Barotha Hydropower Project was the first HPP project in Pakistan. Wherein, during its implementation, the preservation of habitats and biodiversity in the project area commanded attention. From June 1995 upto June 2009 WAPDA played key actor role in formulating environmental and social baseline indicators, supplementary environmental

studies and a decade long monitoring spree. One of the key performance indicators monitored and manages during this whole process was management of wastewater being introduced in the project's area of influence because of project's footprints. As a baseline important water quality parameters i.e. pH, BOD_5 and TSS were recorded and the same were measured during implementation phase of project. The comparison of data revealed that all the KPIs remained within permissible limits and wastewater was managed according to chalked out strategy.

During operation phase the major area of concern is 40 Km Indus River reach from Ghazi Pond to Attock (Khairabad) Bridge. In this reach reduction in water flows during lean periods of the year and introduction of wastewater from point and non-point sources can compromise the downstream water quality. The point and non-point sources of wastewater induction were identified and nine ingress points were earmarked i.e. 5 on left bank and 4 on right bank of Indus. WEC regularly monitored the water quality on these selected locations for more than a decade.

To record the project's footprints on groundwater quality and behavior alongwith any likely waterlogging resulting in saline water generation, 19 selected wells along both bank of river in this reach were monitored. The results of these comprehensive strives are given as under.

Table-I: Wastewater Cum Drainage Channels (ingress points)

(Water Quality)

Construction Period			**Operational Period**		
Parameters	Max	Min	Parameters	Max	Min
pH	8.68	6.76	pH	8.90	5.10
EC µs/Cm	784	181	EC µs/Cm	1275	165
Temp C°	24.7	10.3	Temp C°	33	9.5

Table-II: River Water Quality near Ingress Points

Construction Phase / Period			**Operational Phase / Period**		
Parameters	Max	Min	Parameters	Max	Min
pH	8.82	7.30	pH	9.08	6.50
EC µs/Cm	499	167	EC µs/Cm	363	152
Temp C°	22.5	11.2	Temp C°	33.0	9.6
			DO_2 mg/lit	9.1	5.5

Table-III: Groundwater Quality of GBHP
Range of Water Quality Parameter measured during Project Implementation and Operation
(1995-2009)

Parameter	Units	Range
pH	-	6.8 to 8.1
EC	µs/Cm	302 to 1985
Temp.	C°	20 to 31

Aforestated tabulated data reveals that water quality during and after implementation of GBHP was not compromised. The major driving force behind this positive project impact was ensuring of 28 cumecs of environmental flows downstream of Ghazi Pond in low flow seasons.

3.2 Tarbela 4th & 5th Hydropower Project

Tarbela Dam was constructed in 1974. To enhance its hydropower generation subsequent extensions in power generation have been carried out. In the wake of present energy shortages two further extensions on irrigation tunnels No.4 and 5 were envisaged recently. Implementation of both these extensions is bound to produce substantial amount of wastewater. During feasibility and detailed engineering Design stages the baseline water quality studies were carried out and wastewater management and monitoring sprees were made essential part of ESMP, i.e. Environmental & Social Management Plans. In case of T4th Ext. HPP (under implementation) following measures are being undertaken.

1. A comprehensive surface water monitoring program is being implemented.
2. All hazardous substances are being stored and handled in accordance with their Material Safety Data Sheet (MSDS).
3. Wastewater treatment plant is installed.
4. Solid waste is being dumped at pre-determined dumping sites. These dumping sites are being managed in such a way that, runoff is minimized even during torrential rains.
5. Oils & chemicals are dealt in such a way that their spillage is avoided, if inevitable, it is taken care of.
6. Environmental code of practices pertaining to water quality and wastewater management are made part of ESMP and contract documents; including Environmental Code of Practice-I (ECP-1), ECP-2, ECP-4, ECP-5 & ECP-7.

The main action for management of wastewater at T4th HPP includes regular monitoring of suspended solids and DO_2. Third party and in-house analysis of wastewater by SUPARCO, M&E consultants and Wapda Environment Cell is carried out regularly to record and assess the project's footprints on the surrounding water regimes.

On site management includes collection of wastewater from batching plant in connected settling ponds. In case of increase in effluent and less settling time, supernatant extra wastewater is removed through sucker machine. If there is oil spillage or contamination at Erection Bay, the contaminated wastewater is pumped out of trench and disposed of properly. Fig.1 shows waste water suction Vehicle used for collection and disposal of waste water.



Fig-1: Waste water suction Vehicle used for collection and disposal of waste water.

During feasibility and Detailed Engineering Design of T5th HPP, the baseline water quality monitoring was done. The results are given in Table-3 below:

Table-IV: Baseline Surface Water Quality Monitoring T5th HPP Feasibility and DED Studies.

Month 2016	Monitoring Location	pH	Ph (NSWCC)	TDS Mg/lit	TDS mg/lit (NSWCC)	Turbidity (ntu)	Conductivity µs/Cm
April	Downstream Reservoir	7.1	6.5-8.5	142	500	32.2	0.22
	Intake Reservoir	7.6		114		6.7	0.19
May	D/S Reservoir	7.9		158		32.4	0.27
	Intake Reservoir	8.1		127		5.2	0.29
June	D/S Reservoir	8.2		129		30.1	0.31
	Intake Reservoir	8.2		123		6.5	0.28

It is envisaged that project activities will generate huge amount of sediments and suspended salts during blasting, excavation, spoil disposal and vegetation clearance activities. The mitigation measures include pre-treatment of wastewater to maintain net BOD levels below the standards for effluent discharges to surface waters. Settling ponds will be provided to minimize the risk of contaminated water entering the river or

groundwater thereby degrading the water quality. After completion of construction, contouring and re-vegetation will be carried out to mitigate potential soil erosion and water quality related impacts.

a. Dasu Hydropower Project (Water Quality Baseline)

Baseline water quality study of Dasu's Area of Influence (AoI) was meant for establishing database for water quality parameters prior to project construction. This baseline is going to help in sorting out the impacts of project activities on these parameters, if above NEQS, may lead to adoption of mitigation measures.

The water quality study for the project included collection of statistically valid Indus River water samples around the project area and their analyses. These important analyzed parameters include; Temperature, pH, DO_2, Conductivity, Turbidity, TDS, Sulphates, Nitrates, Arsenic, etc.

Fifteen sampling locations at upstream, dam site and downstream were selected.

Table-V: Baseline Water Quality Parameters for Dasu HPP

Water Quality Parameter	Unit	Range
Water Temperature	C°	15.5 – 21.0
PH	-	7.03 – 8.11
DO_2	mg/lit	7.7 – 12.0
Conductivity	"	11.9 – 96.3
Turbidity	"	0.55 – 70.5
Total Hardness caco3 (Selgoo Nullah only)	"	6.5
Biological Oxygen Demand (5)	"	2.0 – 12.0
Chemical Oxygen Demand	"	3.0 – 21.3
Total Dissolved Solids	"	14.0 – 115.8
Sulphate (SO_4)	"	0.5 – 37.0
		Tangir Dam Nullah Axis
Nitrate (NO_3)	"	0.02 – 3.5
Arsenic (As)	"	0.001 – 0.032

All the parameters are within relevant national and international standards. The wastewater management plan for Dasu HPP has already been inked. We are looking forward to reduce the footprints of environmental activities on water quality to bare minimum.

b. Neelum Jhelum Hydroelectric Project & Wastewater Management

First Initial Environmental Examination study for Neelum Jhelum Hydroelectric Project was carried out in April, 1995. And following feasibility level EIA was completed in 1996. However, in the wake of 2005 earthquake the same was updated with updated baseline. In the updated study it was established that Neelum River water quality was good for agricultural use. However, it must be treated, filtered and chlorinated for domestic use. It

is estimated that 60% of Muzaffarabad's sewage drains into River Jhelum, the river carries away the sewage and provide dilution. To take stock of this situation in the backdrop of project implementation and to take care of riparian users and ecological vigor of 43 Km river reach from Nausary to Domail under regulated water regimes minimum (9+6) = 15 cumecs environmental flows will be ensured in this reach during lean period.

During construction phase of project 33590 m long intricated tunnels excavations proved to be one of the daunting tasks, resulted in generation of huge amount of wastewater from sandstone I & II and shale formations. At all adits / portals of C1, C2, C3 construction sites, wastewater from tunnels is being conveyed through pumpage or gravity flow to the twin rectangular settling tanks. While, finalizing this suspended solids removal system, the efficiency of the system and time period regarding deposition of sediments and frequency of their removal from the tanks was also sorted out. At C1 the size of the tanks is small and efficiency of the system is 60%, while at C_2 & C_3 the efficiency is 80%. Wastewater from batching plants is also fetched to the sedimentation settling ponds and then supernatant is allowed to flow d/s into river. The sludge removal from ponds is carried out as per requirement.

Under Contract Agreement, contractor is bound to comply with wastewater management measures. In case of non-compliance the monitoring is devised in such a way that contractor is obliged to comply. The regular clearing of sedimentation tanks is ensured by the environmental guardians (at site), while WEC countercheck the efficiency of system, as a top supervisory entity, on regular / periodic basis.

Wastewater from workers' camps, offices, residences, and batching plants, etc., is also managed properly. Fig-2 shows settling tanks for wastewater from batching plant.



Fig-2: Shows settling tanks for wastewater from batching plant.

At WAPDA projects the water quality data is compared with national surface water criteria set by Pakistan Environmental Protection Agency (Pak-EPA) under this system

water is classified from AA to D. Classes C&D are most appropriate for the surface waters at WAPDA projects. It means that the wastewater from projects may be treated / managed to such a level that it may fulfill the criteria for C&D, before being introduced in mainstream Rivers. Class 'C' covers "water for propagation of balance growth of fish and other aquatic resources", while class "D", applies to "surface waters that are primarily used for agricultural irrigation and livestock watering and industrial cooling waters."

The moving spirit behind management of wastewater at WAPDA projects is to come up to water quality standards covered under Class C & D, and to avoid contamination of natural water-bodies. This spirit is required to be followed at national level.

Outcome

Water & Power Development Authority (WAPDA) is spearheading the construction of many hydropower projects. The implementation of these projects, as an aftermath changes existing ecosystems. One of the impacts is generation of huge amount of wastewater, during project implementation. WAPDA chalk out wastewater management techniques at design and feasibility levels of project. The measure to be adopted include existing baseline water quality survey, land grading to control surface runoff and soil erosion during and after construction, preservation of natural vegetation to the extent possible, taking care of batching plant wastewater with pollutants including cement, sand aggregates and having high pH, dissolved solids, oil and grease and other chemicals. After sludge removal through sedimentation process, the wastewater is sometimes used for mixing concrete with a tolerance of upto 50,000 PPM of total solids (Portland Cement Association). Handling of domestic wastewater (from labor camps, offices and residential sites) is done on site by providing septic tanks. De-siltation of wastewater in settling tanks originated from tunnels and provision of environmental flows in case of impact of water regulation in downstream reaches of river. Judicious implementation of all these measures lead to sustainable management of wastewater generated at WAPDA projects.

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