FLOATING DEBRIS IN THE STORAGE RESERVOIRS OF BAJINA BASTA AND POTPEC HIDROPOWER PLANT

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Abstract

In recent years it was recognized that there is an increase of floating debris in the water of many rivers and lakes in Serbia. Components of this debris were different from the natural river debris and waste from trees. At same time it was recognized to be similar to municipal wastes.

Because of the debris accumulation in the storage reservoir of the Basta and the Potpec hydropower plants, research was done which gave some answers about the source, assessment of the amount, components, loss of electricity, adverse effects, and mitigation measures. Besides that, such research had to give recommendations for similar problems in other power plants in exploitation such as new ones.

Key words: *floating debris,dam operations, municipal wastes, environmental protection*

Introduction

Study of protection of accumulations of debris with hydro-energetic purpose from covering by river discharge and introduction of surface debris has been conducted in two phases. Several experts from Institute Jaroslav Cerni and Energoprojekt-Hidroinženjering have participated in this project. In this work, some interesting aspects from the analysis of the second phase of that study are presented (1).

HPP (hydropower plant) Bajina Basta is on the Drina River and HPP (hydropower plant) Potpec is in the Lim River. The Lim River is an upstream tributary and belongs to the Drina catchment area. Surface of the Drina catchments area is 19570m^2 and the length of the River Drina is 346 km, with a relief of 432 m and average flow at the point of merging into river Sava of 436.0m^3/sec. Square of Lim catchments area is 5780m^2, length of river is 211km, relief drop is 477m, and average flow at the point of merging is 112,5 m^3/sec. Up to now 9 HPP, 2000 MW capacity and 6400 GWh annual production of electricity have been constructed (2).

Difficulties in work of HPP Potpec are caused by the large amounts of river bedload which is being deposited at the bottom, as well as by the large amount of floating debris. Debris is floating or is deposited, blocking the lattice girders of the dams (Vukosavljevic S. 2000).

An earlier investigation of the floating debris indicates three categories of debris (4):

- Floating debris consists of dead branches, leaves, plastic bottles and bags. Debris covered an area of 15 by 20m, and is at the depth of 0.5-0.7m.
- Suspended debris consists of smaller branches, plastic bottles, plastic bags. Debris is entangled with the organic mud materials
- Settled debris is located at the bottom, and is of 4.5 to 5m height. It consists of tires, plastic packages, and entangled with plastic bags.

Difficulties in the operation of HPP Bajina Basta are caused by the significant amount of floating debris which accumulates over girders decreasing the water inflow and thus hindering production of electric energy. An additional problem is forming of the shell colonies on the girders as well. It is a believed that the increase in the shell number is related to the increase of the organic mater in the lake water and is probably of the same origin as the floating debris is. Based on the reports of the divers, who were manually cleaning the girders, there were some instances where more then 80% of the girders were covered. On this hydropower plant site, no problem with river bedload was observed
Up to this point, problem of the floating debris on the previous lake accumulations was solved by:

- Employing divers for manual removal of the blockage from girders
- Collecting floating debris from the water surface with boats and later transporting it to the local landfill.
- Running it over evacuation organ downstream
- By discharging storage reservoir

All of this was temporary solutions. The worst and most expensive solution was discharging the accumulation (HPP Potpec), because it caused an ecological catastrophe downstream.

Methods

In investigation of the surface deposits we started from the fact that it is an ecological category and that it needs to be studied multidisciplinary. It was clear that the surface deposit which was found in the accumulations of debris was transported from upstream regions by rivers and creeks. Since, river network of Drina upstream from Bajina Basta is settled on territory of 4 states (Serbia, Bosnia and Herzegovina, Montenegro and Albania), field research has been conducted in the upper part of river Drina and Lim and their major tributaries.

It was important to determine if in the accumulations in river network of Drina exists a similar deposit, so we have taken into the account accumulations in the upstream as well. Non field work included a thorough investigation of the internet data-bases on the floating debris, of interest in particular was the research on how local is the experienced problem of floating debris or similar existed somewhere else and was adequately solved. Measures of protection and recommendations were developed only for previously mentioned HPP but they can be applied to the others of similar size, similar characteristics of location and construction, positioned on the rivers with no river traffic. For the rivers with the traffic, like Danube, suggested measures would be only partially efficient.

RESULTS OF RESEARCH

We determined that the floating debris mostly consists of: plastic bags, bottles and glasses, plastic packages, tires, dead branches and tree trunks, aluminum waste, carcasses, and other mud and organic waste materials on accumulations where it was found (Fig. 1 and Fig. 2).

In general literature, floating debris refers mostly to dead branches and three trunks. So it appears that the mentioned content of floating debris is a local character.

Field research was conducted over a period of 30 days and were divided into two trips due to the weather conditions. Because next to the River Drina exists a regional road, sources of waste were present along the River Drina, the River Lim path as well as tributary rivers and streams Many locations were in flooded areas of rivers and streams. That was also visually apparent due to the plastic bags on the branches of trees along the river banks which were in the flooding height. When the water level rises waste along the river sides gets softened and transported from river banks. We have discovered several locations were people were illegally depositing waste from which floating debris was forming. These are:

- non-sanitary landfills
- parks and viewpoints near roads, river banks and channels
- unprofessional behavior of individuals and organizations responsible for collecting and transport waste.

Many city dwellers commonly take their own trash and waste and dispose of it by the road or by the river banks. Light-weighted waste is dispersed by the wind, water, precipitation and even by animals (e.g. birds, rats, dogs). Often the travelers stop at convenient locations by the road to take a rest, or have a meal. Since there are not available rest areas, with tables, restrooms and trash cans, the trash is freely disposed in the environment.

In industrial plants, there are so-called temporary sites for disposal of waste and industrial materials. This means that there is no prepared space for storing industrial materials and there is no organized transport of waste. If kept in open spaces most of waste and industrial materials are dispersed by precipitation.

Fig.1 Hydropower plant Bajina Basta

Fig.2 Hydropower plant Potpec

It seems that the non-sanitary landfills are the biggest sources of floating debris production. In the catchments area of Drina River it has been identified 8 locations of landfills in the 7 municipals. Their characteristics are shown on the table 1.

Table 1. Inventory of municipal waste landfills in catchment area of the Drina river

br	Opstina	Num. of inhab.	See level	Area m^2	Amount of waste ann.m^3	year of begg.	year of closs.	status
1.	Bajina Basta lok.Okuc	12000	-	40000	10000	1980	-	non-sanit.
2.	Visegrad lok. Nezuci	5934	330	5000	3848	1993	-	non-sanit.
3.	Ustipraca lok.Kamenolom	5000	350	2000	5380	1994	-	non-sanit.
4.	Federalno Gorazde	Nisu	dostavlj	podaci			-	non-sanit.
5[1]	Foca, stara dep.Handici	16500	380	6000	15215	1997	2005	non-sanit
5[2]	Foca, nova dep. Babin Potok	16500	380	10000	15215	2005	-	non-sanit.
6.	Rogatica lok. Rudine	5000	743	4000	3000	1978	-	non-sanit.
7.	Cajnice lok. Rudice	5000	900	2000	7000	1996	-	non-sanit.

Table 2. Inventory of municipal waste landfills in catchment area of the Lim river

br	Opstina	Num, of inhab.	See level	Area m2	Amount of wast. ann. m^3	year of begg.	year of closs.	status
1.	Rudo, lok. Zaimpolje	4800	350	40000	1100	1992		non-sanit.
2.	Prijepolje	46709	450	60000	16950	1981		non.-sanit.
3.	Priboj, lok. Dubok potok	35951	460	30000	11000	1979		non-sanit.
4.	Nova Varos Dubok Potok	21812	460	30000	17420	1979		non-sanit.
5.	Bijelo Polje lok. Romsko naselje	55368	480	25000	12000	-		non-sanit.
6.	Berane,lok. Bolnica	38953	720	20000	14400	-		non-sanit.
7.	Andrijevica	6696	870	15000	-	-		non-sanit.
8.	Plav	19305	920	20000	-	-		non-sanit.

When waste reaches rivers and lakes, it floats in the water. After some time spent on its surface, part of waste entangled by plastic bags descends to the bottom. It was noted that the debris appears often after strong rains and floods. Large amounts of water have a consequence of undermining the river banks and washing out the waste downstream. When the water level is not changing too much, the floating debris in rivers and lakes especially, accumulates on gravel and sand bars.

Floating debris can be transported from a few to tens of kilometers downstream. The transport mechanisms are inspected to involve the action of river current as well as the meteorological event. The presence of strong wind, flood and rainstorm can cause the consistent transport of floating debris.

Based on the composition and the source of formation we can conclude that the floating debris is of anthropogenic origin and is located in the close proximity of larger human habitats. On mountain river networks with sparse human population, this debris cannot be found. Moreover, river deposits are of natural sources, and the transport of sediment is the result of the river action and erosion of soil, and source of its production is river network.

Wood fires could decrease the amount of floating debris introducing into stream system. However, fires increase the magnitude of runoff from burned area, increasing the erosion of soil so the amount of river debris decreases. Logging practice could also decrease the amount of floating debris.

Estimation study of electric energy loses caused by the floating debris has been conducted. For HPP Potpeć we have used data for a 6 year period (from 2000-2005). It was estimated that for lost electrical energy of 7.45 GWh yearly, financial loss is 13 million dinars plus lost power of 7.09 MW (estimated with the 318,00din/kW a month, and multiplied by 12 for an annual estimation) is 27 million a year, altogether adding up to 40 million dinars annually.
For HPP Bajina Basta, lost energy power is 8 GWh which is around 14 million dinars annually, and lost power is around 15 MW, two months a year (estimated influence of debris) so that the total estimated loss HPP Bajina Basta is 24 million dinars annually.

CONCLUSIONS

Lake Perućac has the II category water quality, which makes it feasible to be used for recreation and tourism not only for producing electrical energy. The lake is in the close proximity of national park Tara. Therefore, floating debris that is being deposited next to the HPP Bajina Basta, as well as floating waste islands, degrade tourist, recreational and electrical energy potential. Construction design of water gate (barrage) on overflow of the dam doesn't have capabilities of passing the deposits downstream.

That would be possible only in the case of larger water dumping over the overflow which wasn't the practice up till now. Nevertheless, this wouldn't lead to the solution of the problem, it would only dislocate the problem downstream and the problem would spread which is against the law.

HPP Potpec has an overfall, capability of transporting part of the waste downstream, which is being done, but it is a case of poisoning the water network and not solving the problem. It has been determined that observed deposits on both lakes is of anthropogenic source, it has been transported by water from the upstream areas of Drina and Lim.

Protection measures are proposed and based on time and activities they can be divided into two groups:

- short-term (monitoring state of deposit, building in cleaners for removing deposits from girders, forming a special mobile unit for collecting the floating debris form the lake surface and procurement of boats and/or ships for collecting and transportation of the debris to landfill). These are the measures that should be in the annual maintenance plan of the hydro plants.
- Long-term (inter municipal cooperation in the river network, sanitize existing landfills, construction of sanitary landfills out of the flooding areas).

Suggested protection measures are for investigated HPP B.Basta and HPP Potpec. For larger rivers with traffic on them, such as Danube, long-term measures are suggested. Short-term measures wouldn't yield expected results, due to the strong wind influence (košave), waves, constant river traffic in both directions, speed of the river flow in the proximity of the dam etc.

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