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A CASE STUDY OF DHOLBAHA DAM, PUNJAB USING ISOTOPES

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ABSTRACT

Investigations were carried out for water level variation of the Dholbaha dam during May, 2010 to September, 2014 and isotope analysis of the water samples of Dholbaha dam collected on 10 daily basis and rain samples collected on every event basis during June, 2009- January, 2015 was carried out to assess the variations in isotopic composition of reservoir, rain samples and changes due to evaporation. The isotope and water level variations results clearly show the seasonality effects.

Keywords: Isotopes, reservoir, Punjab, water level.

1. INTRODUCTION

Shivalik ranges, the youngest hills of the world have most degraded rain-fed agro ecosystems with acute shortages of drinking water, decreased vegetative cover and soil erosion and in Punjab their peculiar geological formations and proximity to plains, represent the most fragile ecosystem of Himalayan mountainous range (Sud et al., 2000). To fulfill the water requirements, in Punjab state an area of 147.39 km^2 and 8.39 km^2, is under manmade and natural wetland, respectively representing 0.31% of the Punjab area (Sharma et al., 2009). In addition to these, dams have played a major role in defining the ecology of rural areas providing natural drainage and acting as groundwater recharge structures. The drainage channels in the Shivalik range originate on the sloping land in the upper reaches of the watersheds and develop into gullies. A series of such gullies or channels may combine further down to take the form of gorges or ravines. Such ravines merge into seasonal streams towards the lower reaches of a watershed. The main water resources in the area are springs, nallahs, wells, tube-wells and rivers. As many as 17 small dams have been constructed as water harvesting structures in the Punjab Shivalik and the study site, Dholbaha dam is among one of them. It is generally believed that the reservoirs in higher reaches have more impact of seasonal precipitation and evaporation loss (Gibson & Reid, 2010).

The water level in the reservoirs have some seasonal effects and the stable isotopes of water, ^{2} H and ^{18}O, have been used effectively as most powerful tracers in surface water bodies to find source and seasonal effects as during the evaporation process the lighter isotopic molecules preferable evaporate while heavier isotopic molecules accumulate (Clark & Fritz, 1997) and relatively distinguished from other sources as precipitation have very depleted signatures (Gat, 1996).

Although there are publication focusing on the ecological aspects of the region (Sud et al, 2009) but no studies on the isotope analysis was carried out so far. Therefore, present study

was carried out to find out the water level fluctuations and their isotopic characterization for finding the seasonal effects and the optimum water resources management in the area.

2. STUDY AREA

Dholbaha lies in the Bhunga block of Hoshiarpur district, Punjab (Fig. 1) typically sub-tropical climate with temperature variations of 14-47°C in summer; 0°-32°C during winter and average annual rainfall variation of 400-600mm (Sud et al., 2009). For irrigating the farm lands of the nearby villages dam has been built on the khads which used to cause heavy loss to the nearby villages. Dholbaha dam, a earth filled dam is built in 1987 as a part of Shivalik hills lies between latitude 30°34'10.82" and 32°33'02.96" North and longitude 74°50'30.30" and 76°52'51.26" East at an altitude of 390 m with total catchment area 56.14 Km^2 and under water area is 132 ha. Water in the dam existed throughout the year with variations in water level.

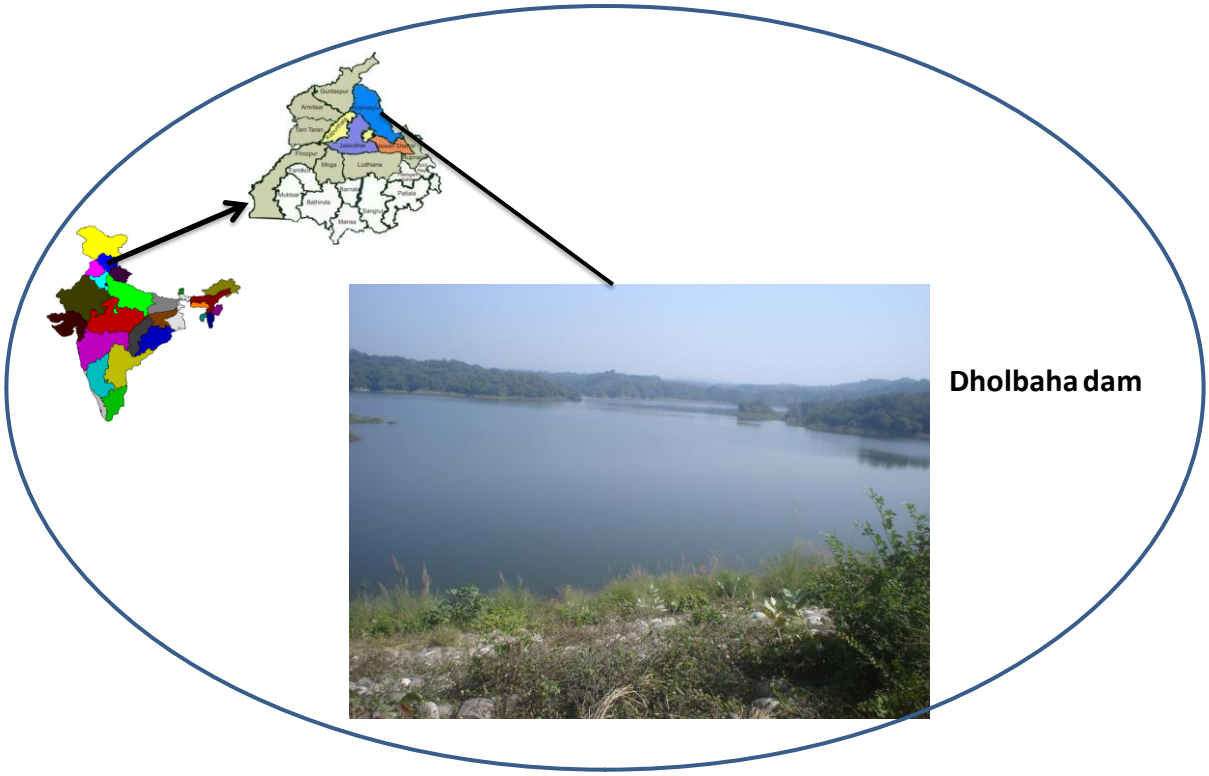

Fig. 1. Dholbaha dam, Punjab

3. METHODOLOGY

The water level measured in the reservoir during May, 2010 to September, 2014. Reservoir and rainfall samples were also collected during June, 2009 to January, 2015 for isotope analysis for the parameters $\delta^{18}O$ and δD. Intensive rainwater sampling was carried out for every rainfall event. Reservoir samples were collected at 9.00 am on 10 daily basis. These samples were collected in 15 ml polyethylene terephthalate bottles, sealed, properly labeled and were stored in refrigerated conditions and transported to National Institute of Hydrology, Roorkee for analysis for both of $\delta^{18}O$ and $\delta^{2}H$ using a DI-IRMS (dual inlet isotope ratio mass

spectrophotometer) with a precision of ±0.01 ‰ ($\delta^{18}O$) and 1.0 ‰ ($\delta^{2}H$). The isotope ratio $\delta^{18}O/\delta^{16}O$ and $\delta^{2}H$ / δH were expressed in per mil units relative to VSMOW.

4. RESULTS AND DISCUSSION

Long term reservoir level data provides useful information on change in base level. The water level changes from 404.84 to 414.18 m with an average value of 409.22m (Table 1). Trend of reservoir level change along with rainfall for the period from May 2010 to June 2013 has been examined for the case of Dholbaha dam (Fig. 2). The plot shows water levels peaking from July end and reaches maximum in November and thereafter starts declining and reaches minimum during April-June and the cycle continues. There is a delay of about 1.5 month from end of monsoon to peak of water level indicating increase in water level due to addition of inflow as a base-flow. In the plot, the sudden drop in the reservoir levels during December probably relates to irrigation releases. The gross water level trend of the reservoir shows a decreasing trend. The rainfall pattern in the same plot also shows a decreasing trend indicating the decreasing rainfall in the region as one of the major cause for the decreasing water level of the reservoir and also the diminishing water resource of the region.

EC measurements were also recorded and it has been found that EC varies between 130-370 µS/cm with an average value 295.5µS/cm. The isotope analysis reveals that the $\delta^{18}O$ values of the reservoir range from −6.83‰ to−0.74‰ with an average value of −3.53‰ while the $\delta^{2}H$ values of the reservoir range from −49.51‰ to −13.40‰ with an average value of −29.47‰ during June, 2009 to January, 2015 (Table 1). For the same period, rain water $\delta^{18}O$ values range from −14.39‰ to 10.85‰ with an average value of −3.70‰ while the $\delta^{2}H$ values of the reservoir range from −115.84‰ to 67.54‰ with an average value of −23.81‰. The rain water values were significantly enriched relative to the reservoir water, however, isotopic line of reservoir water is merging with the precipitation line indicating the precipitation is the source of reservoir water. However, there is a slight deviation of the reservoir water sample line from the local meteoric water line clearly showing the evaporation (Fig. 3).

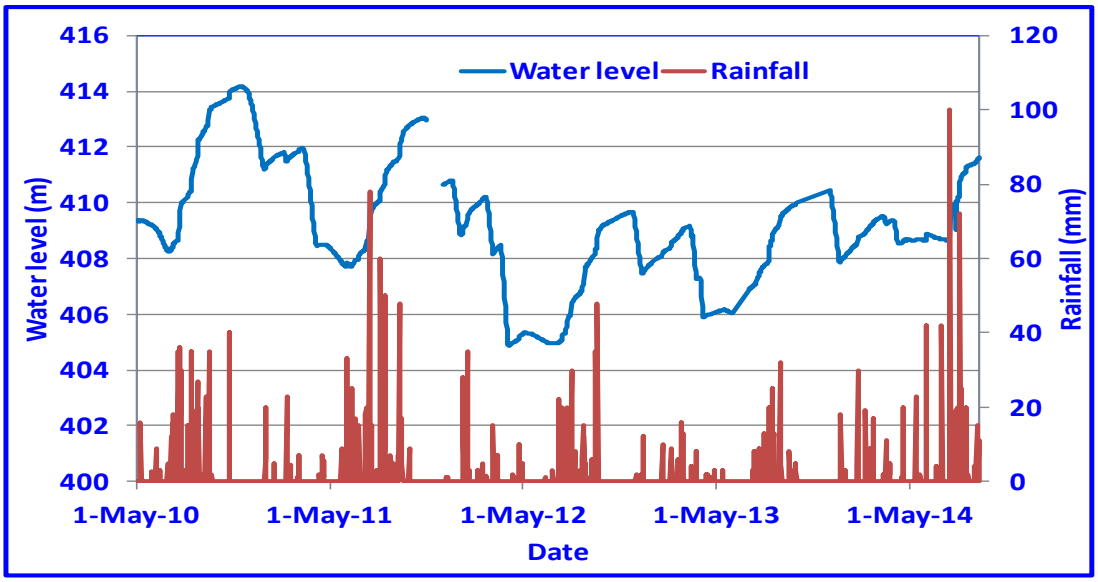

Fig. 2: Water Level and Rainfall pattern of Dolbaha Dam based on monthly data

Table 1: Isotope composition and EC variation

	Reservoir isotope values (‰) n=133		Rain isotope values (‰) n=325		EC reservoir (µS/cm) n=57	Reservoir Level (m) n= 1504
	$\delta^{18}O$	δD	$\delta^{18}O$	δD		
Minimum	-6.83	-49.51	-14.39	-115.84	130.00	404.84
Maximum	-0.74	-13.40	10.85	67.54	370.00	414.18
Average	-3.53	-29.47	-3.70	-23.81	295.50	409.22

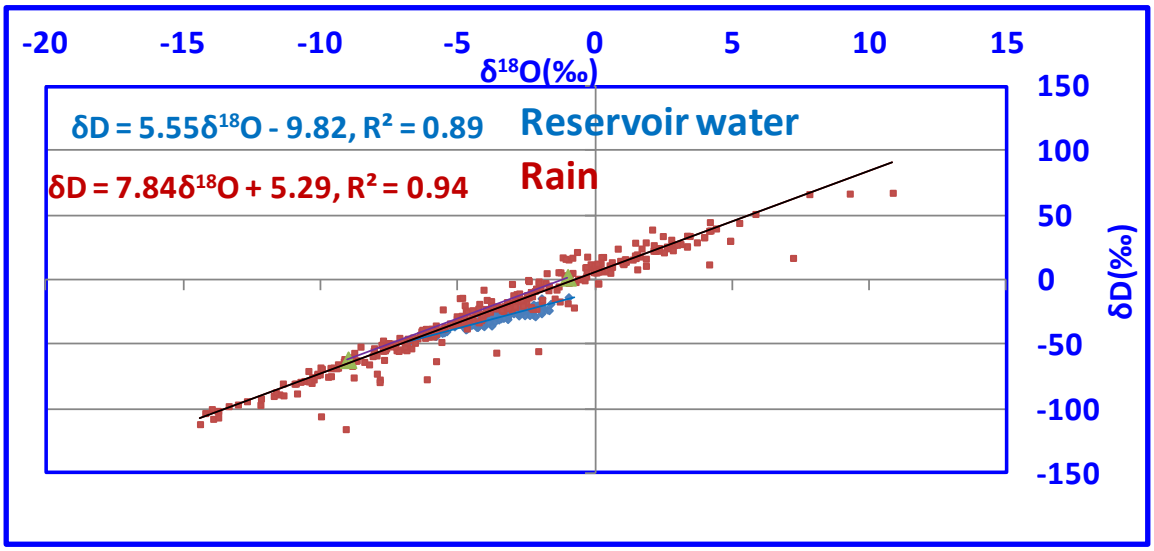

Fig. 3: Isotopic composition of reservoir water and precipitation

The isotope values were plotted against EC values for the years 2011 to 2013 (Fig. 4) and it has been noticed that the variations in the EC values are same as those observed for isotope values but there is a large gap during June 2012 to September, 2013.

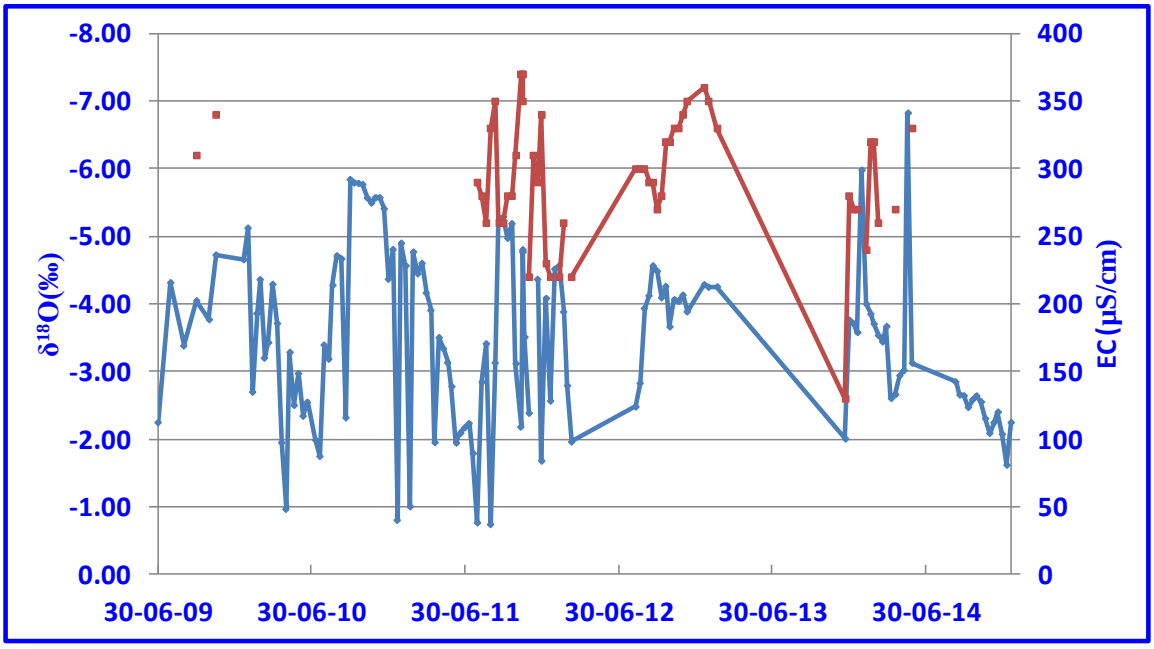

Fig. 4: Variations in isotope values and EC

CONCLUSIONS

Water levels of the Dholbaha dam, start rising from the month of July due to the high input of rain water during monsoon season and maintains high levels till November and thereafter starts declining during the Kharif period and reaches minimum during April-June due to the dry season or less rainfall and this cycle continues. Isotope analysis of the reservoir shows that the water coming to the reservoir has been influenced by the precipitation and there is slight deviation due to the evaporation effect. Isotope values are enriched with higher values during the non-monsoon period and depleted or with lower values in monsoon seasons separating the distinct sources. This study is useful in judicious water resource management of the area.

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