Flood Water DO Determination by new DO-Sag Equation

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Abstract **- Flood water DO determination by application of Streeter Phelps equation is a difficult task, because river velocity and depth during rainy season cannot be determined by conventional surveying methods. During Rainy Season quality of river water deteriorates due to occasional flood. The author is carrying out research investigations on Shivnath River water to assess its quality using Streeter Phelps equation. Therefore DO variation is being monitored over a period of one year i.e. Jan. 2017 to Dec. 2017. Past experience shows that during July-August, extreme fluvial flood event takes place in Shivnath River due to excessive rain fall and discharge of surplus water from Tandula dam. The results showed that water quality is very dynamic during flooding, especially at the beginning of the event. In addition, it was observed that the pathogen and contaminant levels in the flood water are almost as high as in sewers. The finding shows that population exposed to flood water runs a health risk that is nearly equal to that of being in contact with sewer water. As a result, the people of Durg-Bhilai Township not only face physical risk due to flooding, but are also exposed to health risks. Pollution of water bodies, depletion of ground water, lack of drinking water and improper sewage disposal are some of the water related problems encountered due to rapid growth of an industrial township. However, studies of flood water quality dynamics are not often reported in literature, probably due to difficult conditions for sampling during flood events. Therefore authors have extended DO Model study to find out whether Streeter Phelps equation can be applied to assess flood water quality. A unique design of flood water harvesting system is prepared to show its importance as a social welfare project to be implemented on all rivers in the country to protect road side bridges from flood water damages besides managing smooth movement of traffic without and jam.**

keywords **- Water quality-physiochemical parameters, Flood water DO model, Flood water harvesting system, Flood water Management implications, Flood water harvesting**

I.SHIVNATH RIVER- WATER QUALITY IN RAINY SEASON

Flood in Shivnath River is a rare event and in past 10 years hardly there were few occasions when city traffic was affected due to flood problems. During the year 2017 there was no flood but the river was running full during the Rainy Season. The study shows that water quality in rainy season, is different than other season. Over flowing of river water contributes specific characteristics to soil strata around the river bank. This soil produces bulk of its staple food - mainly rice. Having fine texture the black cotton soil is good for "paddy crop". It is found that study and analysis of intrinsic physicochemical properties of water sample of month July to Sep of Shivnath River is useful to estimate their sustainable management requirements. It is noteworthy that the soil becomes slightly acidic to neutral. These soils receive several mineral nutrients annually with the sediments deposited during the monsoon floods. The characteristics like organic matter content, particle size distribution, pH and Calcium magnesium, Sulphates deposits have important business implications such as mining of silica sand, lime stone, promotion of fisheries industry etc. therefore it is revenue generating proposition to commission a suitable Flood Harvesting System on the river.

Months- June to September is classified as Rainy season. Lab test results of Shivnath River water samples during these have been analyzed for water quality parameters.

1. **Water quality assessment** implies the analysis of water samples for above physiochemical parameters. Lab tests results of Temp., pH, Turbidity and Hardness is shown in Table (1).

Table (1)- Variation of Physiochemical Parameters

No.	Parameter	Annual Mean	Rainy	Ideal
1	Temp.	31.10	30.93	30
2	pH	9.28	9.45	7
3	Turbidity	42.97	43.48	5
4	Hardness	225.72	227.33	500

i) **Temperature variation** in Shivnath water between annual mean and Rainy season mean is negligible.
ii) **pH variation** in Shivnath water between annual mean and Rainy season mean is 9.28 to 9.45. This means in rainy season water is slightly more basic. Permissible pH variation on BIS = 6.5 to 8.5 on pH scale.
iii) **Turbidity variation** in Shivnath water between annual mean and Rainy season mean is 42.97 to 43.48. This means in rainy season water is more turbid because permissible Turbidity variation in WHO standard = 5 N.T.U. scale.

iv) **Hardness variation** in Shivnath water between annual mean and Rainy season mean is 225.72 to 227.33. This means in rainy season hardness also increases slightly. Hardness must not be more than 500 in any case.
Fig.(1)- Bar graph is drawn from data given in Table (1), shows variation of all above parameters in comparison to standard values.

2. **Variation of Minerals**- Calcium, Magnesium, Nitrates and Sulphates reported from Lab tests results of Calcium, Magnesium, Nitrates and Sulphates is shown in Table (2).
i) **Calcium variation** in Shivnath water between annual mean and Rainy season mean is negligible. But amount of calcium present in Rainy season (169.69 mg/L) is higher than the permissible limit 7.5 units.

Table (2)- Variation of Physiochemical Parameters

No.	Parameters	Annual Mean	Rainy	Std
1	Calcium	169.69	169.69	7.5
2	Magnesium	11.72	11.71	50
3	Nitrates	21.01	21.31	45
4	Sulphates	13.75	13.85	200

ii) **Magnesium variation** in Shivnath water between annual mean and Rainy season mean is also negligible. But amount of Magnesium present in Rainy season (11.71 mg/L) is lower than the permissible limit 50 units.
iii) **Nitrates variation** in Shivnath water between annual mean and Rainy season mean is 21.01 to 21.31. Although the difference is not appreciable, but presence of Nitrates in rainy season water is less than permissible limits = 45 mg/L
iv) **Sulphates variation** in Shivnath water between annual mean and Rainy season mean is 13.75 to 13.85. Although the difference is not appreciable, but presence of Sulphates in rainy season water is very less than permissible limits = 200 mg/L
Fig.(2)- Bar graph is drawn from data given in Table (3), shows variation of all above parameters in comparison to standard values.

3. **Variation of DO**- Annual mean DO Vs. DO in Rainy Season variation in Shivnath River over 106 km reach, 12 sampling stations is Shown in Table (4).
i) **DO variation** in Shivnath water samples collected over the river stretch 106 km from 12 stations have been tested in the Lab. The annual mean DO values are shown in Table (4)

Table (4)- Variation of DO presence in Shivnath River water in 2017

Sampling Point	Distance Km	Annual Mean mg/L	Rainy Mean mg/L
S1	0	7.37	7.67
S2	22	5.99	6.83
S3	39	5.71	6.87
S4	45	5.82	6.30
S5	60	4.50	4.90
S6	68	3.80	4.50
S7	73	3.44	3.30
S8	85	3.49	3.43
S9	92	3.78	4.87
S10	95	3.96	4.87
S11	99	4.26	4.73
S12	106	4.76	5.13

ii) **DO variation in Rainy season** are tabulated against the annual mean values. It is found that during Rainy season the DO values are higher than corresponding annual mean values. Fig.(3)- DO-Sag curves of Annual mean and Rainy season are drawn from data given in Table (9.4).

Summary of physiochemical Parameters in Rainy Season-

Bhilai is the industrial town of Chhatisgarh, India situated on the bank of Shivnath River Fig.(4). The city is facing typical flooding and water pollution issue during the peak of rainy season. The river Shivnath is a lifeline for the people of Durg and Bhilai as it satisfies the water requirements of the two cities. With the increase in population, development of new colonies and industries, Shivnath has to bear the pressure of untreated sewage & industrial effluents being directly discharged into it. Laboratory results of parameters like Turbidity, pH, Hardness etc. show poor quality of drinking water with potential health risks for the consumers. The surface waters during the event of flooding contained high concentration of pollutants, such as: DO, COD, BOD5. The standard approach of applying dilution factors is no longer valid here due to the similarities observed in pollutant concentrations of surface water and sewage at the time of flooding. Therefore water samples of 3 Locations viz (1)

The Pulgoan bridge- (sample station-7), (2) At Village Kotni (Sample Station -10) and (3) At Village Chikhli (Sample station-12) have been examined for location of flood harvesting system to overcome water scarcity of summer season.
The results of physicochemical parameters are summarized as under:
i) *pH* - It measures the concentration of hydrogen ions and is scale of intensity of acidity or alkalinity of water. It ranges from 7.1 to 8.2. Shivnath water samples show slightly alkaline and is found to be within limits of range prescribed by BIS. ***Colour-*** is "clear" in site-1 & site-2. In site-3 it gets brownish. It's due to the waste water being discharged into the river. ***Odor-***
The water of site-1 is odorless because of sufficient water availability but it gives a slightly pungent smell at site-2 and pungent at site-3. ***Turbidity-*** it is due to dissolution of materials like sand, silt, clay, including some micro-organism or organic materials which may also be present in suspended form. It ranges between 10 NTU to 40 NTU which is crossing the limits as prescribed by BIS at site-2 and site-3. Total Dissolved Solids (TDS) is indicative of salinity of water. If it is high, it may cause scaling on the inner faces of cooking utensils. The TDS value ranged from 214 mg/l to 1885 mg/l. Total Suspended Solids (TSS) Indicates the solids present in the water, in suspension. Basically they are solids but light in weight and don't dissolve. It varies from 93 mg/l at site-1 to 1628 mg/l at site-3.
Total Alkalinity- The acidity of water gets neutralized by total alkalinity. The presence of dissolved carbonates and bicarbonates increase the alkalinity of water sample. The values range from 132 mg/l to 251 mg/l.
Total Hardness- Excess amount of carbonate, chloride and dissolved sulphates cause water to become hard. In this study it ranges from 130 mg/l to 372 mg/l. This states that the water from site-3 is hard whereas site-1 and site-2 are within the limits.
ii) ***Calcium and Magnesium-***
The Ca and Mg concentrations range from 32 mg/l to 67.5 mg/l. The range of Ca is within the limits but Mg exceeds the permissible value. This increased value may act as laxative to human beings.
iii) ***Dissolved Oxygen (DO)-***
DO varies from 3.2 mg/l site-3 to 7.0 mg/l site-1. It is quite obvious that during summer months the quantity of Oxygen dissolved may be less due to high temperature and that too in site-3 because of inflow of sewage with lesser quantity of river water available to dilute it. This is definitely an alarming result. At site-1 there is no in flows from nallahs therefore comparatively better water quality.
Conclusion-
The Physicochemical Parameters of river Shivnath at 3 locations viz 1-near Pulgaon Bridge (Sampling station-7) , 2- Village Kotni (Sampling station-10) and 3- Village Chikhli of Durg (Sampling station-12) Fig. (4). The parameters like pH, temperature, color, Odor, Turbidity, TDS, Ca, Mg, DO where studied with city water supply view point and it is found that all 3 sites are polluted. ***The water of Shivnath is therefore unsafe for direct human use from present intake well position (S7)***.

II.SHIVNATH RIVER: PROPOSED FLOOD WATER HARVESTING SYSTEM

Shivnath river flow route, Fig.(4) occupies the larger part near Durg-Bhilai township and around 1200 km^2 of land area is over saturated during the monsoon to variable depths and durations. The seasonally saturated areas are categorized as wetland and they are classified as grey soils and grey hydro-orphic soils. These soils are good in respect of moisture regime and cultivation of paddy- both local and export quality. Major land uses that support over 10 lacs people residing near the river bank. Though these soils in the past, were considered as fertile for growing traditional wetland crops without using agro-chemicals, but for growing export quality crops require variable doses of chemical fertilization at the present time. During rainy season fishery industry is also promoted. Under changed situation it is, therefore, essential that the intrinsic properties of these soils are determined accurately and evaluated carefully in an effort to stabilize the sustained agricultural productivity of these soils. The seasonal over flow of River water affects Shivnath soil near the bank. It is good for paddy cultivation. Also Flood water harvesting system can be designed to store flood water and use it for irrigation in dry weather.

Frequency of Floods in Shivnath-
Past rain fall record of the area shows that during July-Sep. month in a year the Shivnath River is flooded due to surface drains meeting the river at points on the upstream side. The flood pictures of Shivnath River are shown in Fig.(5). One can imagine the traffic disruption due to floods and ***think of making use of flood water in summer season when water scarcity is felt.*** The flood affects river water quality besides causing damages to roadside bridge made across the river for traffic flow. Although Shivnath River is subject to floods only once or twice in a year during these months, but the losses with respect to water quality and traffic flow disruption are quite heavy. The flood comes due o heavy rainfall in the vicinity of Durg city and discharge of surplus water from Tandula dam in Balod township, or waste disposal streams meeting the river. The intake well of township water supply is near to road bridge on NH-6, which is submerged at times of flood into the river. The flood water spreads over few km on both sides of approach roads of the bridge, thus roads and bridge are damaged and drinking water quality badly deteriorates. Since water quality assessment by Streeter-Phelps equation is based upon stream velocity and, apparently under flood conditions it is difficult to apply it.

III.FLOOD WATER HARVESTING SYSTEM DESIGN

During rainy season Shivnath river flows with full capacity and once or twice in the season it is flooded causing damages to road side bridges, affecting traffic flow and also spread diseases. The aim of ***flood water harvesting*** is to store flood water in artificial, closed ponds made of different materials so that the water can be used during summer season when its scarcity is realized. Flood water harvesting system of a river comprises:
i) Location of commissioning the structures to store River water at the time of floods
ii) Flood Outlet Works – spillway design along river banks Fig. (6)

Practice to Asses Design Data-

a) The Design of storage tank (enclosed with spillway and dam of suitable material Fig.6)

b) The canal system to supply stored water for summer crops, or set a pumping station to supply water to the treatment plant.

Location for Shivnath flood harvesting system-

a) It is observed that ***Shivnath road bridge on NH-6***, is submerged whenever flood situation arises in the River. Therefore ***ideal location for flood water harvesting system*** will be on the upstream side of the bridge. Fig.(6)- flood pictures of the river. The advantage of this site selection is that, the dam designed for storage of water will never allow river water to flow over the bridge. Unfortunately this aspect is overlooked by present engineers and they constructed a new bridge at much higher level, discarding the old one. But the purpose of making new bridge is defeated in flood condition because the approach roads on either of it are submerged in flood water.

b) Design flood for storage dams

When flood takes place in Shivnath past record reveals that flood water spreads on either side of the river bank near the road bridge at Pulgaon naka. Total quantity of overflow water can be estimated from following information:

♣ Population area affected by the flood water = 2 km on either side of the river bank.

♣ River stretch of about 5 km along the bank is submerged by the flood water.

♣ Flood water flows 2.5 m above the road pavement of old bridge site and at the extreme ends of the affected area the depth of water is 0.30 m. Thus average depth of water affected area may be taken as 1.5 m.

c) Flood water spillway design-

Mostly spillways are constructed across a river to store of required water for city supply. But in proposed harvesting system the spillway is provided along both sides of the river bank to allow excess flood water to flow into the reservoir enclosed with an earthen dam Fig.(6).

Flood water is provided outlet through the ***spillway to be constructed along the two banks of the river.*** It has to be designed to accommodate the anticipated peak flood. The structure should be permanent type and should not erode by flood level above required water depth and freeboard ascertained at the site selection and investigations stage. Computation of required length of spillway on each river bank is shown in Table-(5).

Land Area required to build flood diversion structures on either side of river bank is 15 acres. Design of Free over-fall spillway along Shivnath River on each side of Bank = 250 m long. Earthen Dam to enclose flood water reservoir Capacity – 4 x 10_6 M_3 Provide Dam height = 10 m and Dam side slopes on either side = 1:3

Critical length of spillway 'b' at each river bank required is 250 m and the dam is constructed with reservoir material excavated by earth moving equipment outside the spillway location. The dam height is kept 8 m and top embankment is 4 m wide. The inside slope is 1:3 for water storage and outside slope of dam surface is 1:2. Canal head work is made on opposite side of the spillway to allow excess flood to flow through canal. The length of canal is 1.5 km on parallel to approach roads of the bridge. The dam is semi-circular shape in plan with 250 m long spillway forming the diameter. The ogee shaped crest is provided on the spillway having inclined upstream face shown Fig.(6) is provided.

d) Design of earth dam-

Following considerations must be taken care to design the dam to store flood water:

1. Keep pleasant appearance of surrounding areas
2. Construction of required satisfying structures
3. Minimum disturbance of area ecology
4. Excavation depths and tools available
5. Esthetic considerations
6. Economy

Table (5)- Shivnath – Flood Harvesting System design data

No	Particulars	L	B	D	Qty	Remarks
1	Flood water spread over the area along River	5	3	0.002	0.0225	km^3
2	Depth of reservior				5.17	m
3	Area of Reservior				28.74	Say 30 acres
4	Spill way length along the river bank				342.71	Provide 350 m length
5	Estimation of Flood water to be spilled out					m
6	River Bed Contour level = 100 m				100	m
7	Contour Height of Bridge Slab				102.5	m
8	Flood water the top Area- contour				105	m
9	Effective Area to on which flood water in 2 km radius				3141592.65	m^3
10	Volume of spilled water to be stored in two reservoirs				7853981.6	m^3
11	Let radius be x (m) and depth = 10 m				500	m
12	Above storage will be on either side of river				3926990.8	m^3
	bank, therefore each reservoir capacity					
13	Length of Spillway on each river bank				250	m

Shivnath Flood harvesting design data is shown in Table- (5). In simplest form the earthen embankment dam design is shown in Fig. (9.7-A, B and C). Also photograph of a model of flood water harvesting is shown. Data Processing for flood water harvesting is illustrated in ***workSheet-3***- Rows 301 to316.

IV.CONCLUSION

Streeter Phelps equation cannot be applied in case of Flood water DO analysis. The equation demands use of river velocity and depth. It is difficult to measure these two parameters in rainy season. Therefore new DO-Sag equation is employed with lab test results to make DO model for the analysis. As the river Shivnath satisfies the water requirements of the two cities Durg and Bhilai, with the increase in population, development of new colonies and industries, Shivnath has to bear the pressure of untreated sewage & industrial effluents being directly discharged into it. River water samples of Locations: 1) The Pulgoan bridge, 2) At Village Kotni and 3) At Village Chikhli have been analysed for setting up flood water harvesting system. Location 1- Pulgaon bridge is found ideal for following reasons:

i) The flat deltaic region of the Shivnath river system occupies the larger part near Durg-Bhilai township and around one-fourth of these flat lands are seasonally flooded during the monsoon to variable depths and durations.

ii) These soils are rich in moisture content therefore good for cultivation of paddy - both local and export quality the major land uses that support over 16 lacs people residing near the river bank.

iii)

These soils in the past, though were considered as fertile for growing traditional wetland crops without using a gro-chemicals, but for growing export quality require variable doses of chemical fertilization at the present time. During this season fishery industry is also promoted.

V.REFERENCES

[1] Dobbins (R.A. (ed) (1979): *Atmospheric motion and air pollution ,Jhon Wiley and Sons. New York*

[2] Dobbins, W.E.(1964):*BOD and Oxygen Relationship in streams, "J. San. Eng. Div. Proc Amer.Soc Civil Engr. 90(SA3) 53 (1964)*

[3] Dysart, B.C. and Heins, W.W. (1970): *Control of water quality in a complex natural system "IEEE Transactions on system Science and*

Appendix- Figs. & Graphs

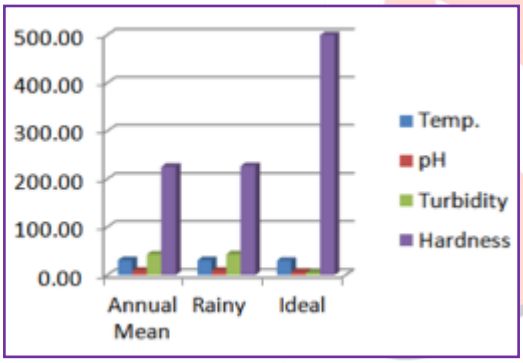

Fig.(1)- (Temp, pH, Hardness & Turbidity)Annual mean Vs. Rainy Season

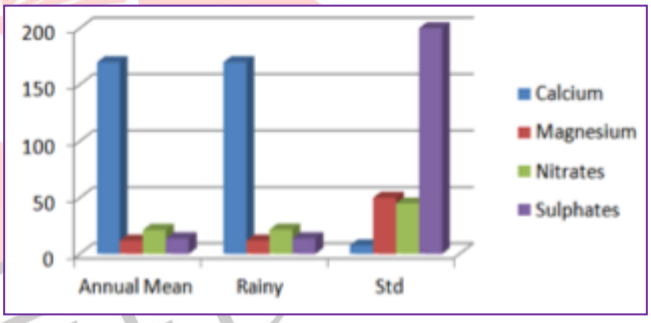

Fig.(2)- (Mineral Contents) Annual mean Vs. Rainy Season

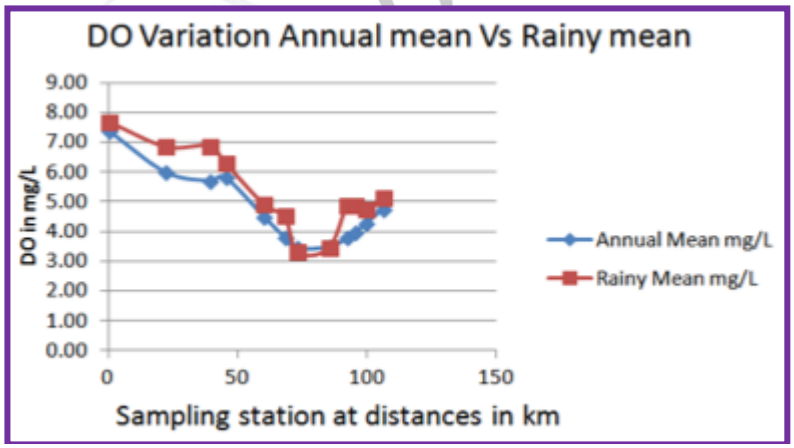

Fig.(3)- DO variation: Annual mean Vs. Rainy Season meanof year 2017

Fig. (4)- DO variation in Rainy season at 3 sites in Durg for city supply

Fig. (5)- Flood in Shivnath (a)- water touching the bridge, (b)- water flowing over the bridge & (c)- water flowing over the bridge

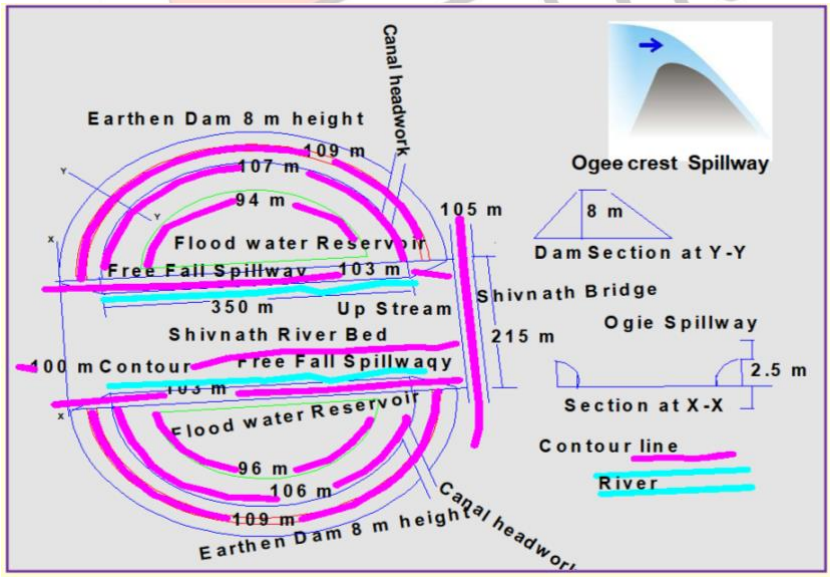

Fig. (6)- Shivnath Flood Water Harvesting System Location & Design

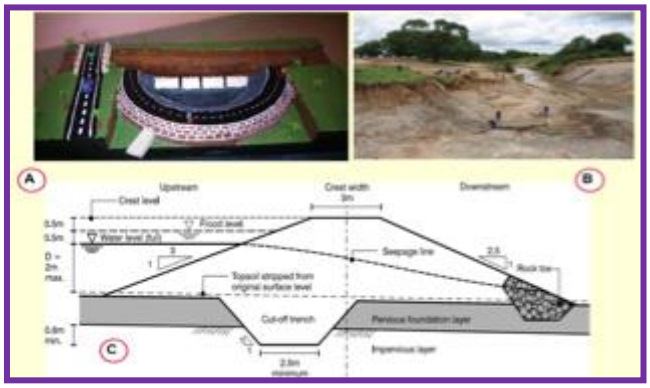

Fig. (7)- A- Model view of Flood harvesting system, B- View of Shivnath river during summer near old bridge and C- typical section of an earthen dam to store flood water.