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Water testing of Swan River in Una District, Himachal Pradesh, India to Analyze Effect of Urbanization

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Abstract: **Water is an essential element needed on planet Earth. UN reported consumable water levels at 2.7% in 1978 of the Earth's water. River water makes 0.2% of all fresh water. The SWAN RIVER INTEGRATED WATERSHED MANAGEMENT PROJECT (SWFMID) has been introduced since 2006 -2007 by the State government of Himachal Pradesh in collaboration with Japan International Cooperation agency (JICA), HP State Forest Department, Agriculture, Horticulture and Animal Husbandry Department. 27 water samples were collected from district Una, Himachal Pradesh, India from three places named Santokhgarh, Tahliwal and Mehatpur. The water samples were collected in the months of December 2014, February 2015 and April 2015. The samples were analyzed on the basis of seven parameters to know the pollution level of water. The observed values were then compared with permissible values in the table given by OIP for water pollution level. By the overall assessment of the parameters of the water samples collected it was concluded that the industries present in those areas are effectively implying the waste water management strategies and hence the pollutant levels are in permissible to slightly polluted levels. As the number of industries is less in Santokgarh as compared to Tahliwal and Mehatpur hence the water quality of Santokgarh was found to be the best amongst the three.**

Keywords: **Waste water management, OIP (overall index pollution), protocol, BOD, COD, parameters.**

I. INTRODUCTION

Civilization of human history started at river banks. Not only the fresh water, but adequate and hygienic water is also needed by any nation. Growing industrialization and increasing population deteriorates the quality of river water. Planned industrial development has accorded top priority by government of Himachal Pradesh. All round infrastructure and industrial development is the key to achieve socio economic progress. It helps in generation of new job opportunities, capitalization and resource advantage. In this changing economic scenario, state government has announced its industrial policies time to time so as to boost the confidence of investors and to enhance the industrial expansion. The state has attracted many investments due to its special incentive packages.

The State government of Himachal Pradesh already has developed 42 industrial area and 17 industrial estates with all facilities like roads, power, water, communication and sewerage etc. Kangra district is followed by Solan where the small scale industries are well established. Now these days Himachal Pradesh has become one of the successful Pharmaceuticals hubs over these years. Una district is considered as biggest industrial center for pharmaceutical sector. The policy also stresses on ecofriendly industrial development for exploration of our local resources, providing quality infrastructure with endless facilities. From last few years with effect from increasing population in urban and semi urban areas, the variety of pollutants has increased in Himachal Pradesh. The water pollution is one of the side effects of industrialization. The drinking water quality of these areas is also getting affected. The assessment of impact of industrialization and urbanization on river water quality can be done by measuring various pollution parameters like ph, alkanity, nitrates, hardness of water, dissolved oxygen, Biological oxygen demand and Chemical oxygen demand.

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The SWAN RIVER INTEGRATED WATERSHED MANAGEMENT PROJECT (SWFMID) has been introduced since 2006 -2007 by the State government of Himachal Pradesh in collaboration with Japan International Cooperation agency (JICA), HP State Forest Department, Agriculture, Horticulture and Animal Husbandry Department. The aim of this project is to achieve sustainable environment and balanced industrial growth leading to more environment opportunities, income generation which help to increase and maintain the infrastructure of state.

Study Area:

The Swan River is a tributary of Sutlej, flows from north to west direction and also known as "River of Sorrow", as flood creates havoc in the area nearby it during monsoons. Major towns located on banks of river are Gagret, Una, Mehatpur, Santokhgarh and Tahliwal. Major industrial areas are Santokhgarh, Tahliwal and Mehatpur. The total length of river is about 85 kms of which 65kms falls in Himachal Pradesh. The type of soil is alluvium, sand and gravel. Water has deteriorated by industrialization and urbanization. Swan River possess above mentioned three industrial area with 50 medium and 575 small scale industrial units located on both banks. Water sample were collected from these areas in the months of December 2014, February 2015 and April 2015.

NAME OF PLACE	LONGITUDE	LATITUDE
SANTOKHGARH	76^{O} 18' 19.7''E	31^{0} 21' 33"N
TAHLIWAL	76^{0} 18' 23''E	31^{0} 21' 59.7"N
MEHATPUR	76^{0} 18' 38.6''E	31^{0} 21' 24.9"N

Industries in the Area:

AREA	UNITS	MAJOR INDUSTRIES
SANTOKHGARH		DISTILLERIES, PHARMACEUTICALS, METALS FINISHING AND CARBIDE MANUFACTURING UNITS.
TAHLIWAL	138	BAKERY, FRUIT PROCESSING, OIL AND OIL CAKE, PAINTINGS, WEAVING, PAINT AND VARNISH, SOAPS , SMALL DIE HOUSE, INDUCTION FURNACES
MEHATPUR	169	PHARMACEUTICAL FORMULATION,IMFI, BOTTLING, SOAPS AND DETERGENTS, CALCIUM CARBIDE, CHEMICALS, METAL FINISHING, ZINC SULPHITE

As the SWFMID project was framed by irrigation cum public health (IPH) Department in order to reclaim the land by providing embankments on both banks to utilize the river water for various purposes i.e; drinking, bathing, irrigation and fisheries, it is important to assess the water quality of river.

II. METHOD AND METHODOLOGY

Different water quality parameters are used to get integrated index for decision making. We use seven parameters for assessment of the water qualities that are given below. Further these values are compared to Classes assigned by OIP. They assigned c_1 to c_5. . The number is known as class index which indicate numerically the level pollution and is the basis for comparison of water quality from excellent to heavily pollute. Table is given as follows:

CLASSIFICATION OF WATER QUALITY BASED ON OIP (overall index pollution)

Table-1

WATER QUALITY	EXCELLENT C_1	ACCEPTABLE C_2	SLIGHTLY POLLUTED C_3	POLLUTED C_4	HEAVILY POLLUTED C_5
PH(MG/L)	6.5 TO 7.5	6.5-6.5 &7.5-8	5-6 & 8-9	4.5-5 & 9	< 4.5 & > 9.5
DO(%)	88 TO 112	75 TO 125	50 TO 150	20 TO 200	<20 TO >200
BOD(MG/L)	1.5	3	6	12	24
NO_3 (MG/L)	20	45	50	100	200
CL^- (MG/L)	150	250	600	800	>800
HARDNESS AS $CACO_3$ (MG/L)	75	150	*300*	500	>500

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Evaluation of Water Quality:

27 water samples were collected from district Una, Himachal Pradesh from three places named Santokhgarh, Tahliwal and Mehatpur. The water samples were collected in the months of December 2014, February 2015 and April 2015. The samples were analyzed on the basis of seven parameters to know the pollution level of water. The observed values were then compared with permissible values in the table given by OIP for water pollution level. The observed values are given below of each month.

MONTH WISE WATER QUALITY OF SWAN RIVER

TABLE-2

1.) DECEMBER 2014:

WATER QUALITY	SANTOKHGARH	MEHATPUR	TAHLIWAL
PH(MG/L)	8.5	7.96	8.1
ALKANITY (MG/L)	1.0	3.0	1.75
NITRATES (MG/L)	50	47	52
HARDNESS (MG/L)	215	208	263
DO %	59	37	62
BOD (MG/L)	2	5	7
COD (MG/L)	16	11	24

TABLE -3

2.) FEBRUARY 2015

WATER QUALITY	SANTOKHGARH	MEHATPUR	TAHLIWAL
PH (MG/L)	8.3	7.99	8.22
ALKANITY (MG/L)	1.2	2.4	1.0
NITRATES (MG/L)	42	59	49
HARDNESS (MG/L)	214	225	231
DO (%)	6.2	3.5	5.8
BOD (MG/L)	2.2	3.9	9.5
COD (MG/L)	14	17	29

TABLE-4

3.) APRIL 2015

WATER QUALITY	SANTOKHGARH	MEHATPUR	TAHLIWAL
PH (MG/L)	8.4	8.01	8.2
ALKANITY (MG/L)	1.0	3.8	1.02
NITRATES(MG/L)	52	45	40
HARDNESS (MG/L)	229	308	275
DO (%)	6.9	3.8	6.9
BOD (MG/L)	3.2	4.5	8
COD (MG/L)	18	12	25

III. METHOD AND PROCESSES USED

Invisible substances in water identified professionally to figure out whether the water is pure or polluted. Testing can be done with portable test kits or mobile or research laboratories. Various processes are as follows:

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A.) pH TESTING PROTOCOL:

1. Rinse each test tube with the water sample. Gloves should be worn to avoid skin contact with the water.

2. Fill the tube to the 5ml line with sample water.

3. While holding a dropper bottle vertically add 10 drops of Wide Range Indicator Solution.

4. Cap and invert several times to mix.

5. Insert the tube into the Wide Range pH Comparator. Hold the comparator up to a light source. Match the sample color to a color standard.

6. Record the pH value and Wash your hands.

B.) NITRATE TESTING PROTOCOL:

1. Fill the sample bottle with sample water. Use gloves if drawing the sample by hand.

2. Rinse and fill one test tube to the 2.5 mL line with water from the sample bottle.

3. Dilute to the 5 mL line with the Mixed Acid Reagent. Cap and mix. Wait 2 minutes.

4. Use the 0.1 g spoon to add one level measure (avoid any 50-60 times in one minute). Wait 10 minutes.

5. Insert the test tube into the Nitrate Nitrogen Comparator. Match the sample color to a color standard. Record the result as mg/L(ppm) Nitrate Nitrogen (NO3-N). To convert to mg/Nitrate (NO3) multiply by 4.4.

6. Place the reacted sample in a clearly marked container. Arrangements should be made with toxic material handlers for safe disposal. Please wash your hands after this water test is completed.

C.) DISSOLVED OXYGEN TESTING PROTOCOL:

1. If you have a barometer, record the atmospheric pressure. Remove the cap and immerse the DO bottle beneath the river's surface. Use gloves to avoid contact with the river.

2. Allow the water to overflow for two to three minutes (This will ensure the elimination of bubbles).

3. Make sure no air bubbles are present when you take the bottle from the river.

4. Add 8 drops of Manganous Sulfate Solution and 8 drops of Alkaline Potassium Iodide Azide.

5. Cap the bottle, making sure no air is trapped inside, and inverts repeatedly to fully mix. Be very careful not to splash the chemical-laden water. Wash your hands if you contact this water. If oxygen is present in the sample, a brownish-orange precipitate will form. The first two reagents "fix" the available oxygen.

6. Allow the sample to stand until the precipitate settles halfway. When the top half of the sample turns clear, shake again, and wait for the same changes.

7. Add 8 drops of Sulfuric Acid 1:1 Reagent. Cap and invert repeatedly until the reagent and the precipitate have dissolved. A clear yellow to brown-orange color will develop depending on the oxygen content of the sample.

8. Fill the titration tube to the 20 mL line with the "fixed": sample and cap.

9. Fill the Direct Reading Titrator with Sodium Thiosulfate 0.025 N Reagent. Insert the Titrator into the center hole of the titration tube cap. While gently swirling the tube, slowly press the plunger to titrate until the yellow-brown color is reduced to a very faint yellow. If the color of the fixed sample is already a faint yellow, skip to step 10.

10. Remove the cap and Tritrator. Be careful not to disturb the Tritrator plunger, as the titration begun in step 8 will continue in step 11. Add 8 drops of Starch Indicator Solution. The sample should turn blue.

11. Replace the cap and Titrator. Continue titrating until the sample changes from blue to a colorless solution. Read the test result where the plunger top meets the scale. Record as mg/L (ppm) dissolved oxygen.

D.) HARDNESS PROTOCOL:

Hardness can be test by following method:

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Hardness, total, sequential

1. Select a sample volume and titration cartridge from *Range-specific information—mg/L* or *Range-specific information—G.d.h.*.

2. Insert a clean delivery tube into the titration cartridge. Attach the cartridge to the titrator.

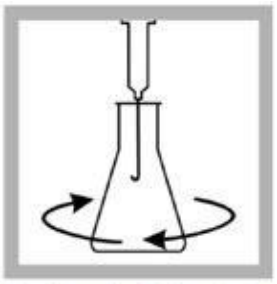
3. Hold the Digital Titrator with the cartridge tip pointing up. Turn the delivery knob to eject a few drops of titrant. Reset the counter to zero and wipe the tip.

4. Use a graduated cylinder or pipet to measure the sample volume from *Range-specific information—mg/L* or *Range-specific information—G.d.h.*.

Transfer the sample into a clean, 250-mL Erlenmeyer flask. If the sample volume is less than 100 mL, dilute to approximately 100 mL with deionized water.

5. If the sample volume is 100 mL, add 2 mL of 8 N Potassium Hydroxide Standard Solution. If the sample volume is 50 mL or less, add 1 mL of 8 N Potassium Hydroxide Standard Solution. Swirl to mix.

6. Add the contents of one CalVer 2 Calcium Indicator Powder Pillow. Swirl to mix.



7. Place the delivery tube into the solution and swirl the flask. Turn the knob on the titrator to add titrant to the solution. Continue to swirl the flask and add titrant until the color changes from red to pure blue.

Write down the number of digits on the counter.

8. Use the multiplier in *Range-specific information—mg/L* (or *Range-specific information—G.d.h.*) to calculate the concentration:

Total digits from step 7 and step 12 x multiplier = mg/L (or G.d.h.) Calcium as $CaCO_3$

E.) BIOLOGICAL OXYGEN DEMAND TESTING:

DILUTION METHOD:

This standard method is recognized by U.S. EPA, which is Labeled Method 5210B in the Standard Methods for the Examination of Water and Wastewater. In order to obtain BOD and dissolved oxygen (DO) concentrations in a sample must be measured before and after the incubation period and appropriately adjusted by the sample corresponding dilution factor. This analysis is performed using 300 ml incubation bottles in which buffered dilution water is dosed with seed microorganisms and stored for 5 days in the dark room at 20 °C to prevent DO production via photosynthesis. In addition to the various dilutions of BOD samples, this procedure requires dilution water blanks, glucose glutamic acid (GGA) controls, and seed controls. The dilution water blank is used to confirm the quality of the dilution water that is used to dilute the other samples. This is necessary because impurities in the dilution water may cause significant alterations in the results. The GGA control is a standardized solution to determine the quality of the seed, where its recommended **BOD5** concentration is 198 mg/l ± 30.5 mg/l.

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BOD5 is calculated by:

Unseeded: BOD_5 = \frac {(D_0 - D_5)}{P}Seeded: BOD_5 = \frac{(D_0 - D_5) - (B_0 - B_5)f}{P}

Where:

D_0 is the dissolved oxygen (DO) of the diluted solution after preparation (mg/l) D_5 is the DO of the diluted solution after 5 day incubation (mg/l)P is the decimal dilution factorB_0 is the DO of diluted seed sample after preparation (mg/l)B_5 is the DO of diluted seed sample after 5 day incubation (mg/l)f is the ratio of seed volume in dilution solution to seed volume in BOD test on seed.

F.) CHEMICAL OXYGEN DEMAND:

The Chemical Oxygen Demand (COD) test measures the oxygen equivalent consumed by organic matter in a sample during strong chemical oxidation. The strong chemical oxidation conditions are provided by the reagents used in the analysis. Potassium dichromate is used as the oxygen source with concentrated sulfuric acid added to yield a strong acid medium. Several reagents are added during the setup of the analysis to drive the oxidation reaction to completion and also to remove any possible interference. Specifically, these reagents are mercuric sulfate, silver sulfate and sulfamic acid. Mercuric sulfate is added to remove complex chloride ions present in the sample. Without the mercuric sulfate the chloride ions would form chlorine compounds in the strong acid media used in the procedure. These chlorine compounds would oxidize the organic matter in the sample, resulting in a COD value lower than the actual value. Silver sulfate is added as a catalyst for the oxidation of short, straight chain organics and alcohols. Again, without the silver sulfate the COD of the sample would be lower than the actual value. Sulfamic acid is added to remove interferences caused by nitrite ions. Without sulfamic acid the COD of the sample would measure higher than the actual value.

G.) ALKANITY:

1. Measure out 100 mL of the water to be tested and pour into a clean while porcelain evaporating dish.

2. With a dropping bottle, add 5 drops of phenolphthalein indicator to the sample. If the solution becomes pink, phenolphthalein alkalinity is present. No color indicates the phenolphthalein alkalinity is zero and this test is complete. No color also indicates free carbon dioxide is present, and the same sample may be used to carbon dioxide test.

3. If pink color results after phenolphthalein indicator is added, add N/50 sulfuric acid slowly and carefully from the burette to the contents of the dish until the coloration disappears. While adding the acid, the contents of the dish should be gently stirred with the glass stirring rod. (A pH meter can be used to determine this end point also since the color disappears at a pH of 8.3).

4. The number of milliliters of the acid required to remove the pink color multiplied by 10 equals the phenolphthalein alkalinity in ppm: that is, each 0.1 mL of the acid used is equal to 1 ppm of phenolphthalein alkalinity. Example: If 2.4 mL of acid were used, the phenolphthalein alkalinity would be 2.4 × 10 = 24 ppm .

IV. RESULTS

WATER QUALITY ASSESSMENT COMPARES WITH OIP VALUES:

WATER QUALITY	EXCELLENT C_1	ACCEPTABLE C_2	SLIGHTLY POLLUTED C_3	POLLUTED C_4	HEAVILY POLLUTED C_5
PH	6.5 TO 7.5	6.0 -6.5 & 7.5-8.0	5-6 & 8-9	4.5-5 & 9	< 4.5 & >9.5
DO (%)	88 TO 112	75 TO 125	50 TO 150	20 TO 200	<20 TO >200
BOD (MG/L)	1.5	3	6	12	24
NO_3 (MG/L)	20	45	50	100	200
CL^- (MG/L)	150	250	600	800	>800
HARDNESS $CACO_3$ (MG/L)	75	150	300	500	>500

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A.) DECEMBER 2014

WATER QUALITY	SANTOKHGARH	MEHATPUR	TAHLIWAL
PH (MG/L)	8.5	7.96	8.1
ALKANITY (MG/L)	1.0	3.0	1.75
NITRATES (MG/L)	50	47	52
HARDNESS (MG/L)	215	208	263
DO (%)	59	37	62
BOD (MG/L)	2	5	7
COD (MG/L)	16	11	24

From the above table it is found that the water sample of Santokhgarh is slightly polluted. There is Acceptable ph level in Mehatpur and Tahliwal.

- Samples indicate higher number of Nitrates level in Tahliwal.

-Hardness of water sample is in acceptable to slightly polluted range.

-DO level lies in excellent range in all the three areas mentioned above.

-As per BOD and COD levels, the water sample of Mehatpur and Tahliwal is slightly polluted as compared to Santokhgarh.

B.) FEBRUARY 2015

WATER QUALITY	SANTOKHGARH	MEHATPUR	TAHLIWAL
PH(MG/L)	8.5	7.96	8.1
ALKANITY(MG/L)	1	3.0	1.75
NITRATES (MG/L)	50	47	52
HARDNESS (MG/L)	215	208	263
DO (%)	59	37	62
BOD (MG/L)	2	5	7
COD (MG/L)	16	11	24

From the above table ph level of Mehatpur and Tahliwal is slightly polluted as compared to Santokhgarh.

-Higher alkanity is found in Mehatpur.

-Nitrate level is high in Tahliwal and Mehatpur.

-Hardness level is found in the range between acceptable to slightly polluted range.

-DO level lies in excellent range.

-BOD and COD levels are found higher in Tahliwal and Mehatpur as compared to Santokhgarh.

C) APRIL 2015

WATER QUALITY	SANTOKHGARH	MEHATPUR	TAHLIWAL
PH (MG/L)	8.4	8.01	8.2
ALKANITY (MG/L)	1.0	3.8	1.02
NITRATES (MG/L)	52	45	40
HARDNESS(MG/L)	229	308	275
DO (%)	69	38	69
BOD (MG/L)	3.2	4.5	4.8
COD (MG/L)	18	12	25

It is found in the above mentioned table that:

-pH level is nearly acceptable in all the three areas according to the given permissible values in Table No. -1.

-Santokhgarh and Tahliwal are having low alkanity level as compared to Mehatpur.

-Nitrates level is between acceptable to slightly polluted range in all the three areas.

-Hardness level shows slightly polluted range.

-DO % values are found in slightly polluted range.

-BOD and COD lie in acceptable to slightly polluted range in all three areas.

V. CONCLUSION

By the overall assessment of the parameters of the water samples collected it was concluded that the industries present in those areas are effectively implying the waste water management strategies and hence the pollutant levels are in permissible to slightly polluted levels. As the number of industries is less in Santokgarh as compared to Tahliwal and Mehatpur hence the water quality of Santokgarh was found to be the best amongst the three.

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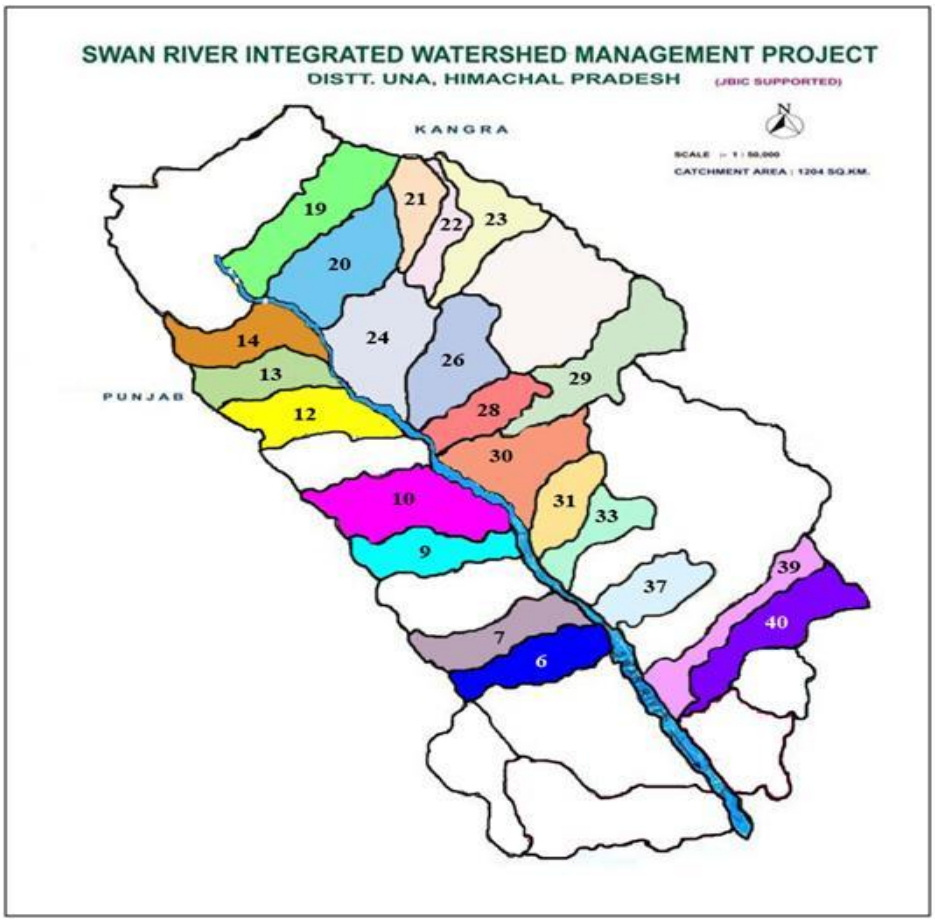

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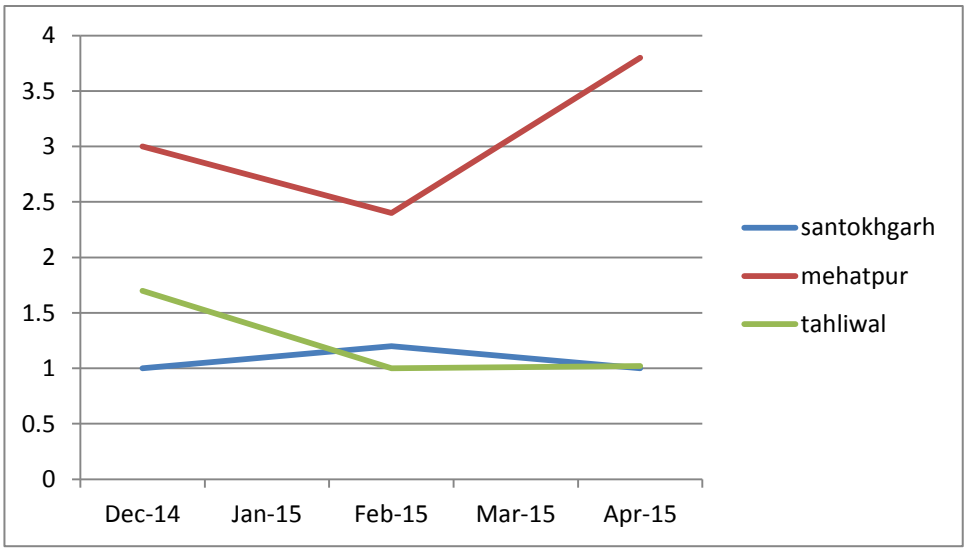
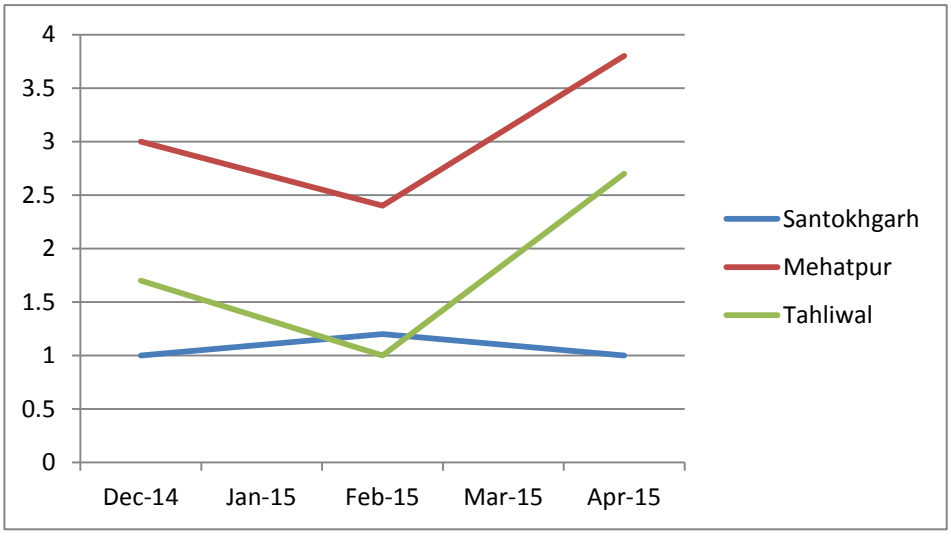
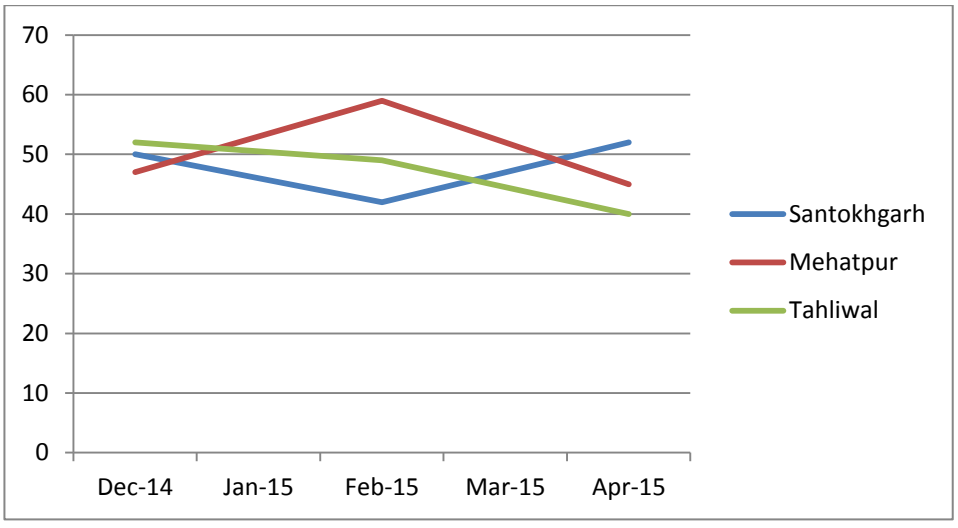
pH SHOWN BY THE GRAPH OF SWAN RIVER



GRAPH SHOWING ALKANITY:



Graph showing Nitrate level:



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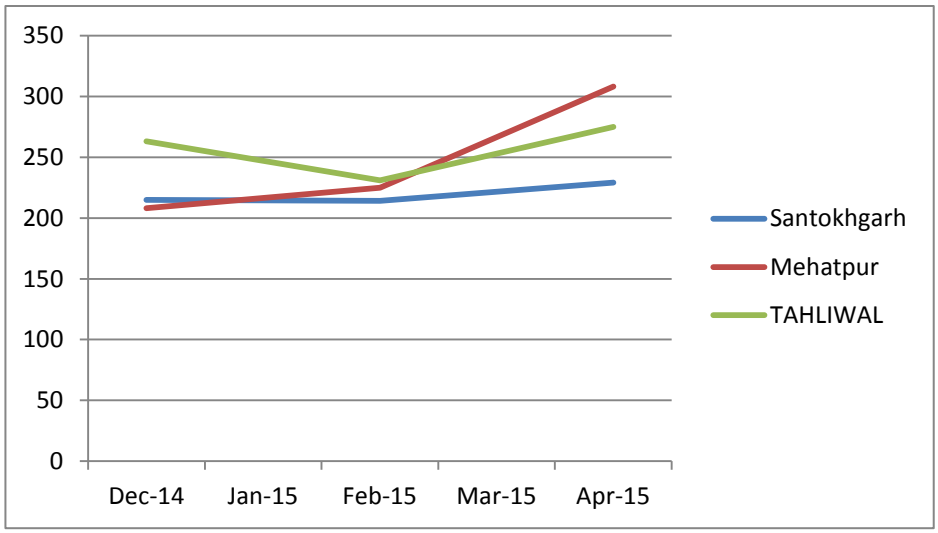
GRAPH SHOWING HARDNESS:



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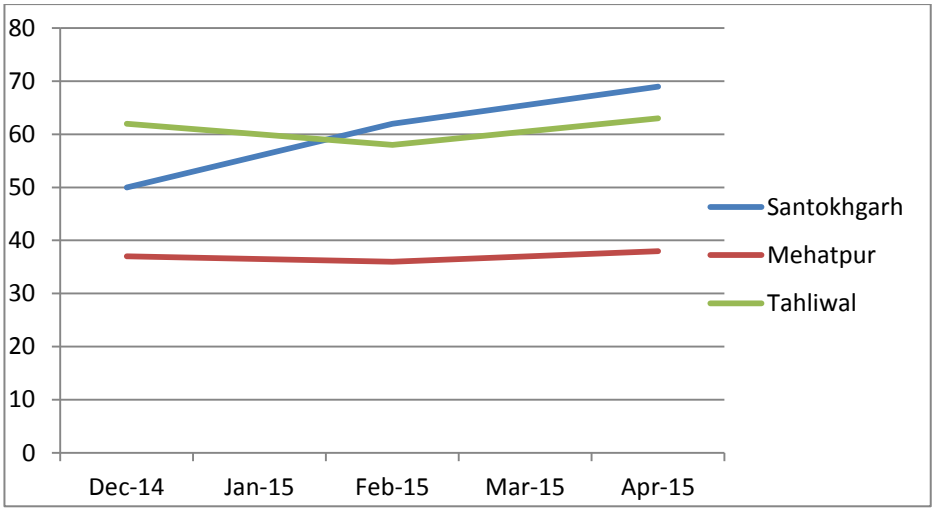
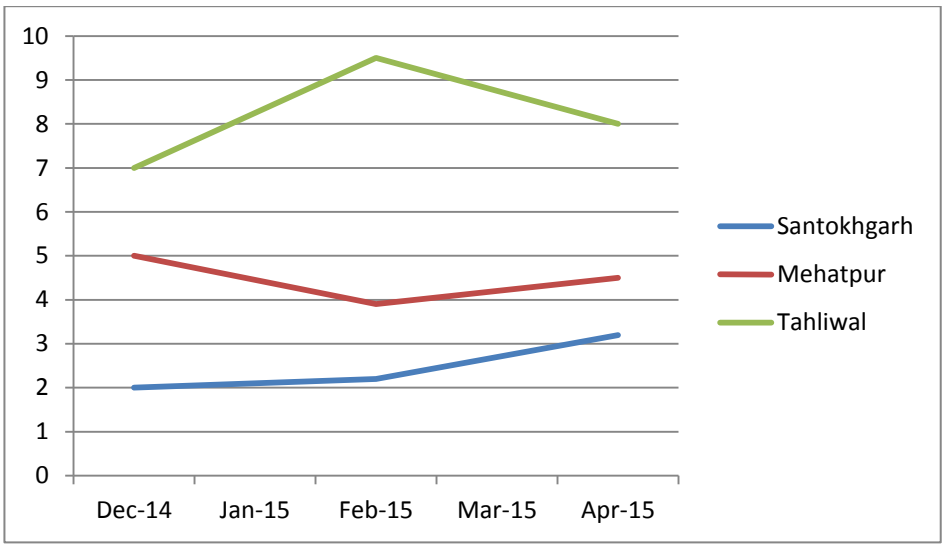


GRAPH SHOWING BOD:



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GRAPH SHOWING COD: