Parameters of water Quality

This chapter deals with the material used and methodology adopted during the course of investigation. The study was conducted during pre-monsoon, monsoon and post-monsoon season in the year March 2011 to February 2012 at Rajghat Dam, Sagar (M.P.).

The aquatic ecosystem has been a topic of great interest for ecologists. The stagnant and running waters are routinely studied by many researches, water supply organization and pollution control authorities with various objectives. The aquatic ecosystem are ideal system for studying various ecological functions. The study of these systems is not only fascinating but is highly important for human welfare and sustenance.

In the present study internationally accepted standard methodology prescribed in limnological literature was adopted as far as possible. Initially all the relevant historical and topographical details of the water body were collected from the different specialized sources. Thereafter, the field trials and standardization analytical procedures were made. After getting a basic idea about the biogeochemical nature of the water body, a regular uninterrupted monthly sampling was carried out for 12 months between 2011 to 2012 covering all the three prevailing seasons of this region. Monthly sampling was done in first week of every month. Sampling was done between 10:00 to 12:00 hours on two alternate days from 4 sites of the Dam.

A field kit containing standard glasswares reagents, water sampler, Secchi disc, century water analysis kit (Ck 710) light and black pointed BOD bottles of 300m capacity, graduated pipettes (1 to 10 ml capacity) droppers, polythene bottles, tubes enamel trays, measuring tape, rope, polythene bags labeling materials buckets preservatives and field accessories were carefully carried to the field. A boat was engaged thought the study period for sampling. Before commencing field work a temporary laboratory was set up in side the boat.

The following important precautions were taken before sampling and analysis of the sample
(1) Care had been taken to avoid disturbance of surface water due to boat movement.

(2) Cleaned and dried collection bottles were rinsed with the sample to be collected.

(3) Marking of sampling sites and labeling of sample on the sites which were strictly ad lured to.

(4) As much as possible the minimum duration of time between one sampling sites to the other were kept.

(5) Same water parameters were estimated immediately after sample collection.

(6) A bucket was used to despair off the analysed sample for preventing the contamination of water with chemical reagents.

Water samples were collected for the analysis of physico-chemical parameters.

**Physical parameters**

1. Water temperature
2. Water colour of odour
3. Tranparency/Turbidity (detected by Secchi Disc)
4. Conductivity
5. pH
6. Alkalinity

**Chemical parameter**

7. CO₂ (Carbon di oxide)
8. Dissolved Oxygen (O₂)
9. Chemical Oxygen Demand (COD)
10. Biological Oxygen Demand (BOD)
11. Chloride
12. Calcium
13. Water hardness- Is it physical or chemical parameter
14. Sodium
15. Potassium
16. Magnesium
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Biological parameter
(a) Plankton and
(b) Fish growth

Physical Parameters

This chapter deals with physical parameters. This includes the water parameters such as temperature, colour and odour, turbidity, conductivity pH and alkalinity. There parameters are important as they reflect the water quality changes in rainfall pattern, topography, vegetation and human activities. The physical parameters are as following:

Temperature

Materials – 100 ml beaker, Mercury thermometer with 0.1% graduations.

Procedure:
(1) Recorded the air temperature by holding the thermometer upright in the air
(2) Aid about 314 of a 100 ml beaker with the sample and held the thermometer in upright position. The bulb of the thermometer was completely immersed in water.
(3) Observed the mercury level and
(4) Noted the reading in Celsius when the reading became constant.
   (i) Temperature measurement was taken before and after the discharge of waste water to detect the source of thermal polluter.
   (ii) Temperature difference (ST) between two sampling points (temperature at affected site temperature at a control site) can also be used to detect thermal pollution. The temperature difference or change was used to calculate water quality index.
   (iii) The temperature was immediately measured after collecting the water samples.
   (iv) The bulb of the thermometer was not exposed to direct sunlight while taking the readings.
   (v) It is important to take temperature reading at the same time of the day and season, as the readings have to be compared over a period of time.
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Conversion chart for temperature expression:

\[ ^\circ C = \frac{(F - 32.0)}{1.80} \]

\[ F = (^\circ C \times 1.80) + 32.0 \]

When \( F \) = Fahrenheit

Colour –

Light coming from the Dam surface fields an apparent colour which is the result of the true colour of water (due to materials in solution), seston colour (due to living and non-living particulate matter), and the reflections of surface and sub-surface objects. The colour is best judged by observing through a water telescope or also by observing colour of white quadrat of Secchi disc with the standard empirical colour scale (or oven by visual observations).

Empirical flourle colour scale is the most often used this measurement and can be prepared by mixing different perspirations of cobalt ammonium sulphate as shown in the table.

Table- The flourle colour scale

<table>
<thead>
<tr>
<th>Solution</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
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<td>Colour</td>
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<td>Blue</td>
<td>Green</td>
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<table>
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</tr>
</tbody>
</table>

Solution

1 = 0.5g CuSO₄·5H₂O+5ml strong NH₄OH to 100 ml H₂O
2 = 0.5g K₂CrO₇·5H₂O + 5 ml Strong NH₄OH to 100 ml H₂O
3 = 0.5g CoSO₄·7H₂O + 5 ml Strong NH₄OH to 100 ml H₂O
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Odour

Odour is generally measured as “threshold odour number” which is equal to dilution ratio of the sample at which the odour is just detectable. The sample is diluted with odour free water until a least perceptible odour is detected by the tester. As the sensitivity to odour of different persons varies, therefore minimum 5 persons and permeably 10 or more should observe the samples for odour. There persons should not suffer from cold or any disease which interferes with the sense of smell.

Samples for odour determination were collected in glass bottles with glass stoppers and the test was completed soon after the collection of samples. If the test has to be delayed, the samples were stored in refrigerator avoiding any more odour to enter the bottles at low temperature.

Transparency /Turbidity

Secchi disc method- Turbidity measurements were based on the transparency of the water body. This was determined directly in the field by using a Secchi disc. A Secchi disc is a device used to measure turbidity of lakes rivers and stream and reservoir. It consists of a circular plate or disc made of any hand and heavy metal such as iron. The diameter of the plate is 20cm with the surface painted with attenuate black and white quarters. It is attached to a calibrate line by a ring at the center which is held by a rope, which hangs vertically.

Materials- Secchi disc, long rope, measuring tape or scale.

Procedure

(1) Lower The Secchi disc was slowly lowered into water until it just disappeared from view.

(2) Note down the depth at which it just disappeared by noting the length of the rope (L₁).

(3) Lower the disc further down and slowly raise it until it reappears.

(4) Note down this depth at which it just reappears (L₂).
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Calculation

(i) Calculate the average of these two reading for the final disc depth \( \frac{L_1 + L_2}{2} \)

(ii) The procedure was repeated thrice

(iii) An average of three reading were calculated to get a fairly good measurement.

\[
\text{Euphoric limit} = \text{SDT} \times 1.5
\]

where 1.5 is a constant.

(i) Reading was taken only in bright sunlight under a shade with the sun preferably overhead or the disc facing the sun

(ii) The surface of the Secchi disc were made clean.

(iii) During strong wave, waited till the wave action reduces.

(iv) The reading were influenced by the subjective impressions

(v) Cloudy weather and ripples in water were avoided as would affect the reading.

pH

Chemicals – Standard pH tables of pH 4.00 pH 7.4 pH 9.2 and distilled water.

Materials- pH meter, thermometer and 100 ml beaker.

Preparation of buffer solution- Buffer solution are solutions which are resistant to changes in pH. They maintain a constant pH and are used as standard solutions in pH determination. To prepare buffer solutions dissolved standard pH tablets of pH 4.0 pH 7.4 and pH 9.2 separately in 100ml distilled water.

Procedure – Only after accostomizing with the operation of pH meter it was used.

(i) Put the switch on and dip the electrode code in distilled water and adjust the meter to pH 7.0

(ii) Dipp the electrode in the buffer solution of pH 4.0.

(iii) Turne the selector switch to the pH range of 0-7.0 and adjust the buffer Knob. to pH 4.0, move selector switch to zero.
(iv) Remove the electrode from the buffer and wash it with distilled water. Dippe the electrode in a buffer of pH 9.2 Adjusted the buffer knob to pH 9.2. Now the meter is calibrated to both the pH range i.e., 0-7 and 7-14.

(v) Moved the selector switch to zero. Removed the electrode from the buffer and washe it with distilled water then dipp in the water sample.

(vi) Record the temperature of the sample.

(vii) The selector switch to pH range of 0-7 was moved the pH value of the sample was recorded of pH exceeded to 7, moved selector switch to pH of 7-14 and recorded the pH value.

(viii) Turn the selector switch to zero before then switch off the instrument and remove the electrode.

(ix) Keep the electrode dipped in distilled water when not in use.

Measurement of pH was made in the field itself or as early as possible because biological activities or chemical changes in a water sample could alter the pH by as much as 0.5 to 1.0.

Alkalinity

Carbonate and bicarbonate alkalinity: Alkalinity of water samples was analysed trimetrically using 0.02N sulphuric acid in the presence of phenolphthalein and methyl orange as indicators. Different types of alkalinity were detected when followed the method described by APHA (1985) and Trivedy and Goel (1986).

(a) Carbonate alkalinity- Carbonate alkalinity of water was analyzed by titrating 100 ml of water sample of different sampling sites with N/50 sulphuric acid using four drops of phenolphthalein as indicator, until the pink colour just disappeared. The amount of N/50 sulphuric acid in titration was noted, carbonate alkalinity was expressed as mgL⁻¹.

$$\text{Carbonate alkalinity as mgL}^{-1} = \frac{\text{ml of titrant 'p' x 1000}}{\text{ml of sample}}$$

where ‘p’ ml of titrant used for phenolphthalein indicator
(b) Bicarbonate alkalinity- Bicarbonate alkalinity of water sample of different sampling stations was measured by titrating 100 ml sulphuric acid using two drops methyl orange as indicator until the faint orange tint colour was obtained. The amount of N/50 sulphuric acid used in titration was noted. Bicarbonate alkalinity was expressed as mgL⁻¹.

Bicarbonate alkalinity as mgL⁻¹ = \frac{\text{ml of titrant } \times 1000}{\text{ml of sample}}

where “t” total value of titrant and for methyl orange indicator.

**Conductivity**-

Electrical conductance is the ability of a substance to conduct the electric current. In water, it is the property caused by the presence of various ionic species.

**Materials** – Conductivity meter, transparency tubes, beaker, etc.

It is generally measured with the help of a conductivity meter having a conductance cell containing electrodes of platinum coated with Pt. black or carbon. These electrodes are mounted rigidly and placed parallely at a fixed distance. Conductance, when measured between the electrodes having a surface area of 1 cm² and placed at a distance of 1 cm, is called electrical conductivity and is the property of the water sample, rather than the measuring system. The term specific conductance is also used in place of electrical conductivity, but is an obsolete term. The unit of conductivity measurement is Siemens (S) cm⁻¹. The older unit mho cm⁻¹ is now rarely used. The conductivity of most waters is generally low so the unit µs cm⁻¹ shall be much appropriate.

As the ionization of the solutes depends on the temperature, conventionally the results are reported at 25°C.

**Procedure**

(1) It is measured with the help of a conductivity meter. Followed the instructions supplied by the manufacturer.
(2) Conductance depends on the area of the metallic electrodes and the distance between them. The factor used to convert the observed conductance into conductivity is called as the “Cell constant” cell constant of the ‘Conductance cell’ is usually supplied by the manufacturer.

(3) Note the temperature of the sample and find out the factor from table. Convert the values at 25°C.

**Factors for converting the values of conductivity at 25°C** (After Gloterman *et al.*, 1978)

<table>
<thead>
<tr>
<th>ºC</th>
<th>Factor</th>
<th>ºC</th>
<th>Factor</th>
<th>ºC</th>
<th>Factor</th>
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<td>13</td>
<td>1.27</td>
<td>3</td>
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</tr>
</tbody>
</table>

Conductivity = Observed conductance × Cell constant × Temperature at 25°C
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Chemical Parameters

This part deals with the assessment of chemical parameter such as carbon dioxide (CO2), Dissolved oxygen (O2), Chemical oxygen demand (COD), Biological oxygen demand (BOD), Chloride, Calcium, water hardness, Sodium, Potassium and Magnesium, etc. These parameters and their quantities reflect the degree of pollution of the water body and also to some extent changes in the composition of water body. Methods, which require simple instrumentation are described which yield result that are accountable to a large degree.

Free carbon dioxide and Total Carbon dioxide (CO₂)

Free carbon dioxide was estimated titrimetrically as per method given by APHA (1985) and Trivedy et al. (1987). Water samples were titrated with 0.02273 N, sodium hydroxide solution using a few drops of phenolphthalein indicator. The free carbon dioxide in mgL⁻¹ was computed by the formula:

\[
\text{Free CO}_2 \text{ mgL}^{-1} = \frac{\text{ml of titrant used} \times \text{Normality of titrant} \times 44 \times 1000}{\text{ml of water sample}}
\]

Total carbon dioxide was calculated from the free carbon dioxide, carbonate and bicarbonate and alkalinity by the formula followed by (Adoni, 1985).

\[
\text{Total carbon dioxide mgL}^{-1} = \text{mgL}^{-1} \text{ of free CO}_2 + 0.68 \ (A+B)
\]

where, \( A = \text{mgL}^{-1} \text{ of bicarbonate alkalinity} \)

\( B = \frac{\text{mgL}^{-1} \text{ of carbonate alkalinity}}{2} \)

Dissolved oxygen (O₂)

It was analysed by using modified Wrinkler’s method. The samples of surface and bottom water were taken in a narrow mouth glass stoppered BOD bottles of 300 ml capacity. To avoid entering of atmospheric oxygen it was immediately wrinklerised by adding 2 ml of manganous sulphate and alkaline potassium iodide solution. The resultant brown colour precipitate was dissolved by 2 ml of concentrated sulphuric acid. Then 50 ml of this treated sample was titrated against
N/40 sodium thiosulphate solution using starch as indicator APHA (1985), Trivedy and Goel (1986).

\[
\text{Dissolved oxygen} = \left( \frac{8 \times 1000 \times N}{V} \right)
\]

where,  
N = Normality of titrant, \( \nu \) = Volume of titrant used  
V = Volume of sample  
It was expressed in mgL\(^{-1}\)

**Biological Oxygen Demand (BOD)**

BOD is the amount of oxygen required by microorganisms to stabilize the biologically degradable organic matter under aerobic conditions. Water samples in 300 ml BOD bottle were incubated for five days at 20°C inside a BOD incubator. After five days of the incubation period, the DO was estimated in the samples by modified Winkler’s Iodometric Method as described earlier. The few water samples of the Rajthat Dam which were collected during summer season exhausted their oxygen before completion of the incubation period. Such samples were diluted with BOD free water and the initial DO was estimated in the diluted sample. Dilution factor was also calculated.

BOD in water sample was calculated by the followed formula:

\[
\text{BOD mgL}^{-1} = D_0 - D_5 \times \text{dilution factor}
\]

where, \( D_0 \) = initial DO in the water sample  
\( D_5 \) = DO sample after 5 days of incubation period  
Dilution factor was used only for diluted samples (APHA, 1985, Trivedy and Goel, 1986).

**Chemical Oxygen Demand (COD)**

The amount of organic matter in water was estimated by their oxidability by chemical oxidants such as potassium permanganate or potassium dichromate (constituents e.g. carbon and hydrogen are oxidized and not nitrogen). In the permanganate method, the organic matter was first oxidized with a known amount of
KMnO₄ and the excess of oxygen was allowed to react with potassium iodide to liberate iodine in amount equal to the excess oxygen which was estimated titrimetrically with sodium thiosulphate solution using starch as an indicator.

It was analysed titrimetrically by potassium permanganate digestion method using standard 0.1m sodium thiosulphate as a titrant and starch as an indicator (Adoni et al., 1985).

To 50 ml sample aliquot in an Erlenmeyer flask 0.5 ml of 0.1 N potassium permanganate reagent was added and the flask was placed in a boiling water bath for 1 hour. Then the flask was cooled for 10 min., later 5 ml of 10% potassium iodide reagent and 10 ml of 2 M sulphuric acid were added and then titrated with 0.1 M sodium thiosulphate reagent using starch indicator. A distilled water glass blank was used. with each set. COD in water sample was calculated by the formula:

$$\text{COD mgL}^{-1} = \frac{8 \times C \times (A - B)}{S} \times 0.23$$

where,

- $C$ = Concentration of titrant (M/mL)
- $A$ = Volume of titrant used for blank (ml)
- $B$ = Volume of titrant used for sample (ml)
- $S$ = Volume of water sample (ml)

Result was expressed as mgL⁻¹.

**Chloride**

The chloride content was estimated by Argentometric method (APHA, 1985, Trivedy et al., 1987) by titrating the sample with 0.0141 N silver nitrate solution in the presence of potassium chromate as indicator.

The concentration was calculated by substituting the concordant value of the result of titration in the formula:

$$\text{Chloride mgL}^{-1} = \frac{\text{ml of AgNO}_3 \text{ solution used} \times \text{Normality of AgNO}_3 \times 35.5 \times 1000}{\text{ml of water sample}}$$
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**Hardness**

Hardness was estimated by EDTA titrimetric method as described in APHA (1985) and Trivedy *et al.* (1987). A solution of sodium salt of Ethylene Diamine Tetra Acetic Acid (EDTA) was used as titrant with the mixture of sodium chloride and ammonium purpurate as indicator for calcium hardness in the presence of 8 percent NaOH solution. Eriochrome Black – T in the presence of ammonia buffer was used as indicator for total hardness. The values of calcium and total hardness were calculated as mgL⁻¹ of CaCO₃ using the followed formula:

\[
\text{Calcium hardness} = \frac{\text{ml of titrant used} \times 1000}{\text{ml of water sample}}
\]

\[
\text{Total hardness} = \frac{\text{ml of titrant} \times 1.05 \times 1000}{\text{ml of water sample}}
\]

The magnesium content was estimated by calculation method outlined in APHA (1985) and Trivedy *et al.* (1987).

**Sodium and potassium**

Sodium and potassium content in the reservoir water sample were estimated by flame photometer (Systromics-121) followed the method given in APHA (1985) and Trivedy *et al.* (1987). Water sample was filtered through Whatman No. 44 filter paper to remove suspended matters and then the reading was recorded from the meter scale of flame photo-meter. The final values of sodium and potassium contents were obtained by comparing the observed reading with the standard curves which were prepared from different known concentration of sodium and potassium stock solutions. The results were expressed in mgL⁻¹.

\[
\text{Na, mgL}^{-1} = (\text{mgL}^{-1} \text{ K in diluted aliquot}) \times \text{dilution factor}
\]

\[
\text{K, mgL}^{-1} = (\text{mgL}^{-1} \text{ K in diluted aliquot}) + \text{dilution factor}
\]
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Calcium

Many indicators such as ammonium purpurate, calcon, etc. from a complex with only calcium but not with magnesium at higher pH. As EPTA is having a higher affinity forwards calcium. The former complex is broken down and a new complex is formed. However, EDTA has a property to combine with both Ca$^{++}$ and Mg$^{++}$, therefore, magnesium is largely precipitated as its hydroxide at sufficiently higher pH.

Procedure

(i) Take 50 ml sample in a conical flask if the sample is having higher alkalinity use smaller volumes diluted to 50ml.

(ii) Add 2.0 ml of NaOH solution in the sample.

(iii) Add 100 to 200 mg of murexide indicator, a pink colour develops.

(iv) Titrate against EDTA solution until the pink colour changes to purple. For better judgment of end paint. Compare the purple colour with the distilled water blank titration end point.

Calcium, mgL$^{-1}$ = $\frac{x \times 400.8}{\text{ml of water sample}}$

Where $x$ = Volume of EDTA used.

Magnesium

Calcium and magnesium form a complex of wine red colour with Eriochrome Black-T AT pH 10.0. The EDTA has got a stronger affinity for Ca$^{++}$ and Mg$^{++}$ can be obtained by subtracting the value of calcium from the total of Ca$^{++}$ + Mg$^{++}$.

Procedure

(i) Find out the volume of EDTA used in calcium determination.

(ii) Also find out the volume of EDTA used in hardened (Ca$^{++}$ + Mg$^{++}$) determination with same volume of the sample as taken in the calcium determination.
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(a) \( \text{Mg}^{++} \text{mgL}^{-1} = \frac{y - x \times 400.8}{\text{Volume of sample} \times 1.645} \)

where, \( y = \) EDTA used in hardness determination
\( x = \) EDTA used in calcium determination for the same volume of the sample.

(b) \( \text{Mg}^{++} \text{mgL}^{-1} = \frac{\text{Total hardness (as mgL}^{-1} \text{CaCO}_3) - \text{Calcium hardness (as mgL}^{-1} \text{CaCO}_3) \times 0.244}{\text{Volume of sample}} \)

where, Calcium hardness (as \( \text{mgL}^{-1} \text{CaCO}_3) = \text{Ca mgL}^{-1} \times 2.497 \)

Plankton Collection and Analysis (Biological)

Plankton samples were collected from sub-surface at all stations and preserved simultaneously, while taking samples for physico-chemical analysis. Planktons were collected by means of samples from the reservoir and filtered through bolting silk net (No. 25). The net was conically designed having a diameter of 30 cm and length of 60 cm. In the lower narrow part of the net, a transparent plastic tube of 50 ml capacity was fixed. Sixty litres of the reservoir water was carefully passed through net. The filtrant was transferred carefully to plankton collection tube of 50 ml capacity and preserved with 5% formaline and brought to laboratory.

The collected samples were concentrated by centrifugation at about 2500 rpm using table top centrifuge. The supernatant was removed carefully by dropper and 3 drops of glycerine were added. Only 5 ml was kept as final volume.

Fish growth analysis

Fish growth and its analysis were done by the method as described by Tandon and Oliva (1978), Johal (1980) and Jhingran (1982,1991). For measuring the growth under the influence of varying physico-chemical and food factors the fishes will be kept in aquatic habitat in an inverted mosquito net type of fish net. The net was 10-10-10 feet in size which had a partition at 5 feet length. Thus dividing the inverted mosquito net in to two equal chambers the bottom of the net was tied with long chambers at two feet height from the base like wise the middle and top of the fish net was tied with strong rope to bamboo. It was so designed that the whole net can be
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collapsed and shifted to desired place in the Dam. The net was tied with the bamboos and fixed at a particular location and covered by another net from the top. This was to prevent the escape fishes and to protect the caged fish from other fish eater aquatic animals like water snake, tortoise etc. Two such nets were installed/fixed at all sites/locations quite apart in the Dam. This size of the holes of net was such as to allow phyto-zooplankton but not to allow the fish to escape. Any change in the characteristics of the water in the surroundings will automatically change the aquatic environment of cage water. After fixing the bamboo and net at the site of the Dam, 15 fishes in each were put into 4 cages A, B, C and D. Each cage had three types of fish species.

Although the cages will be examined every day but for recording the parameter for growth, cages will be taken out on fifteenth of every month after recording the parameters of growth the fishes will be put back into the cage. This is the easiest way to record the growth of the fishes in natural habitat. Can will be used to avoid any shock to fish that can inhibit the growth in any way.

Construction of four transportable enclosed net was done in such a way that the good part of net remained immersed is water during summer when water level of the Dam depleted at four study points then the nets were shifted to deeper water. All the nets were opened four feet above the water level four sides and lower side were tied with net with small size to prevent the escape of fishes.

Statistical analysis standard error is calculated with the help of computer software Instate.