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Research Note

Role of Electrical Conductivity as an Indicator of Pollution in Shallow Lakes

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Abstract: A major portion of water based recreational activity of human race centres around the thousands of lakes, reservoirs and other small, relatively quiescent bodies of water, which has drawn the attention of the researchers to a great extent during the recent times. Water quality is closely linked to many physical and chemical aspects of lake. Control on various physical, thermophysical and chemical properties of lake water has to be maintained so that their values remain within permissible limits. Electrical Conductivity (EC) is such a thermophysical property of lake water, which has strong interrelationship with pollution level. Experiments carried out at Subhas Sarovar (lake) and Rabindra Sarovar (lake), Kolkata, indicates that EC has a linear relationship with Total Dissolved Solids (TDS), which is validated by the findings at various other lakes throughout the world. Since EC increases with temperature, the values are corrected to a standard value of 25°C and then are technically referred to as specific electrical conductivity. It is also observed that EC increases with increase in TDS, which in turn indicates increased concentration of sulphates and other ions. Therefore, measured value of EC indirectly indicates the level of pollution in lake waters and further studies on the sources of pollutants and possible remedies can then be made. Moreover, measurement of EC is much easier than direct measurement of TDS, thus showing an easier path for pollution monitoring in shallow lake waters.

Key words: Electrical conductivity, lake, pollution monitoring, total dissolved solids.

Introduction

Electrical Conductivity (EC) is the ability of water to conduct an electrical current. It is a vital thermophysical property of water. Dissolved ions in the water are conductors. The major positively charged ions are sodium (Na^+), calcium (Ca^{+2}), potassium (K^+) and magnesium (Mg^{+2}). The major negatively charged ions are chloride (Cl^-), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}) and bicarbonate (HCO_3^-). Nitrates (NO_3^{-2}) and phosphates (PO_4^{-3}) are minor contributors to conductivity. The commonly used unit of EC is microSiemens per centimetre (μS/cm). Natural rivers and lakes have conductivities between 10 and 1000 μS/cm. The dissolved, or soluble fraction of the water's total solid load, is referred to as total dissolved solids (or salts), abbreviated as TDS. It is normally measured in milligram/litre (mg/L). Dissolved ions increase salinity as well as conductivity; therefore the two measures are closely related. Generally EC and TDS increase with depth. The bearing of EC on temperature is well established. It is found that EC increases with temperature of water. TDS can increase due to several reasons; soil and rocks release ions into the waters that flow through or over them. The geology of a certain area will determine the amount and type of ions. TDS can

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also increase due to other sources such as atmospheric deposition and activities of people like agriculture, drainage, urban run-off, waste disposal, etc. Increase in TDS beyond certain limits indicates water pollution and aquatic life gets significantly affected. It has been observed by a number of researchers that EC increases with increase in TDS (Samal, 2001). A linear relation exists between TDS and EC and it is seen that TDS (in mg/L or ppm) can be calculated by multiplying the conductance by a specific factor (usually between 0.55 and 0.75). An increase in this factor in turn indicates increase in concentration of sulphates and other ions (Gray, 1999). Therefore, it is obvious that the measured value of EC indirectly indicates the level of pollution in lake waters and on the sources of pollutants. Hence, the present study concentrates on a simple but elegant method for determining the level of pollution in water, especially in shallow lakes, by measurement of EC alone. This will definitely reduce the effort needed for direct measurement of TDS, which is much cumbersome in comparison to measurement of EC (Michand, 2001).

Results and Discussion

Experiments were carried out on Subhas Sarovar (lake) and Rabindra Sarovar (lake), Kolkata where it was observed that EC is very closely related to TDS in spite of the fact that it is directly proportional to the rise in temperature.

The experiments were carried out during the first week of April i.e. during the summer season. The location was chosen just in the mid of the lake and the time of sampling was 1440 hrs. Since the location was in the mid of the lake both for Subhas Sarovar and Rabindra Sarovar, it can be considered that it was free from disturbances that took place near the banks due to bathing of few hundred people everyday.

Figures 1 and 2 show the variation of EC with depth in Subhas Sarovar and Rabindra Sarovar respectively, and it is clearly shown that the EC goes on increasing as we go downwards. Figures 3 and 4 show the variation of TDS with respect to depth in Subhas Sarovar and Rabindra Sarovar respectively and it shows that TDS also increases as we go downwards. As all the EC values were corrected to 25°C the variation of EC with respect to temperature was nullified. Therefore it can be easily concluded that the variation of EC was due to TDS. So from the curve of EC one can easily conclude about the amount of TDS in lake water.

Figures 5 and 6 show the TDS vs EC curve for Subhas and Rabindra Sarovar respectively and it is seen that the amount of TDS varies almost linearly with EC of the

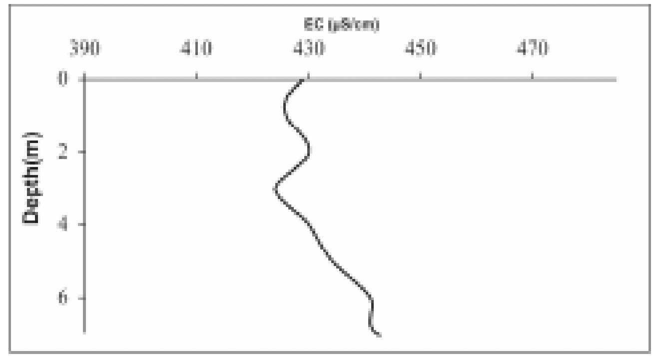

Figure 1: Variation of EC with depth at Subhas Sarovar.

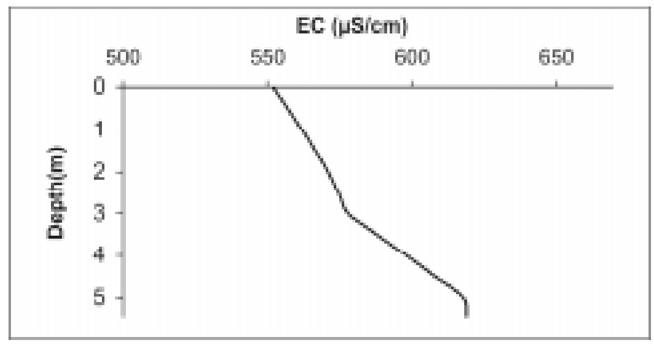

Figure 2: Variation of EC with depth at Rabindra Sarovar.

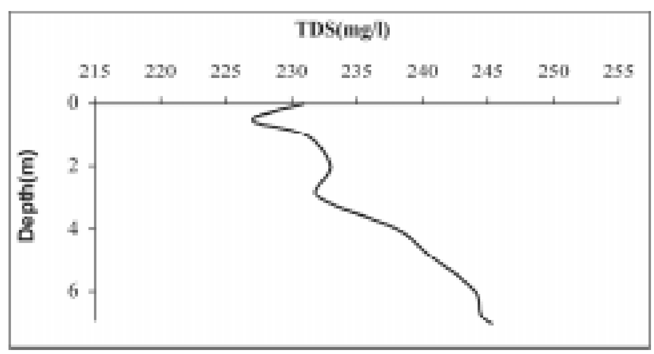

Figure 3: Variation of TDS with depth at Subhas Sarovar.

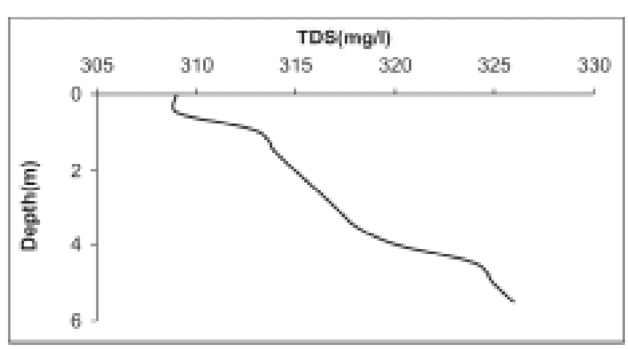

Figure 4: Variation of TDS with depth at Rabindra Sarovar.

water. Thus EC is a clear indicator of the amount of TDS and extent of pollution in that area. From both the curves we see that the EC value has not exceeded the 500 µS/cm mark and it is well below the danger level which is 1000 µS/cm for natural lakes and rivers.

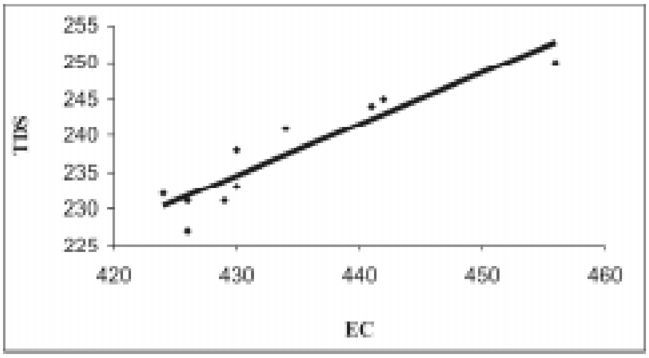

Figure 5: Variation of TDS with EC at Subhas Sarovar.

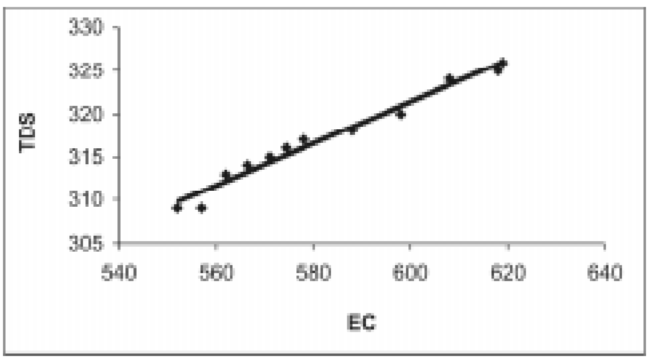

Figure 6: Variation of TDS with EC at Rabindra Sarovar.

The average TDS/EC ratio is found to be 0.547 for Subhas Sarovar and 0.544 for Rabindra Sarovar, which match well with established research works. As the ratio increases with increasing sulphate concentration, it gives an idea about the pollutants.

The TDS/EC ratios of some other important lakes of the world are given in Table 1.

Table 1: TDS and EC Values of Different Lakes of the World

Water body	*EC (µs/cm)*	*TDS (mg/L)*	*TDS/EC*
Divide Lake	10	4.6	0.46
Lake Superior	97	63	0.64
Lake Tahoe	92	64	0.69
Grindstone Lake	95	65	0.68
Ice Lake	110	79	0.71
Lake Independence	316	213	0.67
Lake Mead	850	640	0.75
Great Salt Lake	158,000	230,000	1.46

The influence of TDS on density ρ is described by β, which can be termed as the Co-efficient of TDS and is given by Equation (1) (Imboden and Wuest, 1995).

$$\rho \text{ (along the depth)} = \rho_o[1+ \beta \times \text{TDS}] \qquad (1)$$

where β = co-efficient of TDS and ρ_o = surface density.

The different values of β were obtained by putting the values of TDS and density at different depths of the two lakes. Figures 7 and 8 show plots of β against depth, which give a more or less cubic trend in both the cases. Therefore, it reveals that if β and surface density for a particular lake is known one can find out the density using these equations at different depths having known TDS values (obtained directly from EC values) without performing the test for density separately, thus saving a lot of time for rigorous experimentation.

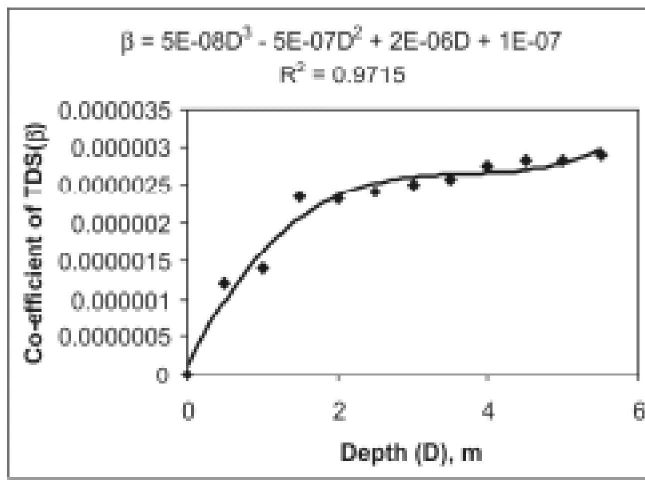

Figure 7: Variation of coefficient of TDS vs depth at Subhas Sarovar.

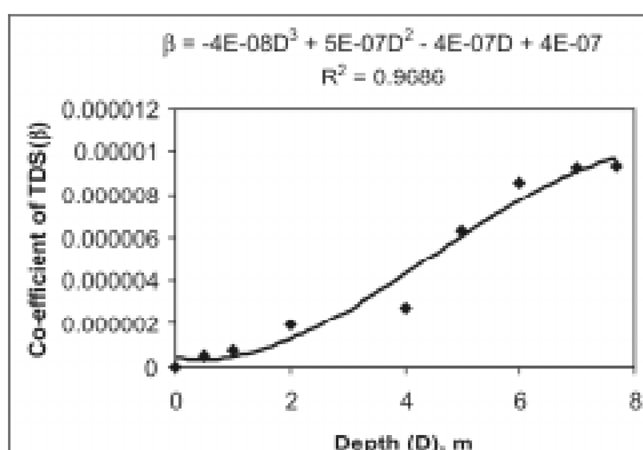

Figure 8: Variation of coefficient of TDS vs depth at Rabindra Sarovar.

Conclusions

The present study shows an easier path for estimation of TDS and density of shallow lake water at different depths by measurement of EC and surface density only. The equation put forward here is expected to give fairly accurate results. However the constant in the equation may get changed depending upon the location and owing to change in meteorological and morphological condition. Therefore, researchers have to ascertain those constants for particular lakes following the same procedure mentioned here, and then those equations can be used for further estimation of TDS and density.

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