Ministry of Environment, Forest and Climate Change

Department of Fisheries
GOVERNMENT OF MEGHALAYA

Integrative Taxonomy and Microbial Ecology Research Group (ITMERG)

OFFICE OF THE DORBAR KHLIEHSHNONG ★ SOHRA ★

RAPID HABITAT ASSESSMENT
OF KHLIEHSHNONG WATER RESERVOIR, MEGHALAYA

Supported by:

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Background

Freshwater ecosystems are pivotal for biodiversity and offer innumerable socio-economic opportunities including blue upskilling. Mapping the habitat including at scales of biodiversity, physical and chemical gradients are an integral component for freshwater ecosystems to attain holistic management including by stakeholders such as indigenous and local communities. Under the NERAQ (Protection and Sustainable Management of Aquatic Resources in the North-Eastern Himalayan Region of India) project commissioned by German Federal Ministry for the Environment, Nature Conservation,Nuclear Safety and Consumer Protection (BMUV) under the International Climate Initiative (IKI),a pilot project is being implemented in Khliehshnong. a village located about 3.5 km away from Cherrapunjee in Meghalaya. The project intends to establish a Snakehead Visitor InformationCentre and conserve endemic species of Snakehead fish in a local water reservoir that can ultimately contribute to blue economy through aquatic tourism and support livelihood of local communities.

Broad Objectives

a. Rapid habitat assessment of the Khliehshnong water reservoir for potential suitability towards ranching
b. Capacity development of the frontline staff members of different government departments towards monitoring health of aquatic ecosystems such as Khliehshnong water reservoir

Methodologies

The rapid habitat assessment was undertaken across the Khliehshnong water reservoir on 23rd July, 2024. The team led by Punyasloke Bhadury undertook in situ measurements of key habitat parameters of the Khliehshnong water reservoir and collected variety of samples that could provide a critical understanding of the habitat (Figure 1). The air temperature (AT; °C) and surface water temperature (SWT; °C) were measured using a digital thermometer (Digi-sense RTD meter 20250-95, single input thermometer with NIST-Traceable Calibration) while dissolved oxygen (DO; mg/L) was measured using handheld DO meter (Hanna instruments HI98198, EU-with temperature sensor).

Figure 1: Habitat assessment including collection of samples from Khliehshnong water reservoir

The pH was measured using a pH probe (Hanna instruments HI98190, EU-with temperature sensor); electrical conductivity (EC, µS/cm) and total dissolved solids (TDS, ppm) were measured using TDS/EC meter (Hanna instruments HI9819-EC/TDS/Resistivity/ Salinity Meter with temperature sensor, EU). The Secchi depth was measured by deploying the Secchi disc (cm; LaMotte, France). All these measurements were undertaken across 6-7 points covering the entirety of the reservoir. In addition, surface water samples were collected for undertaking estimation of dissolved nutrients, quantifying concentration of metals, assessing the total dissolved carbon concentration, assessment of key biodiversity components as well as assessment of the presence of emerging contaminants. The estimation of dissolved nutrients was performed using 50 mL of collected water samples. The samples were filtered through 0.45 μm 25 mm nitrocellulose filter paper (Milipore, Germany). The concentrations of dissolved ammonia, dissolved nitrate (Finch et al. 1998), dissolved o-phosphate (Strickland and Parsons 1972) and dissolved reactive silicate were determined using a UV-Vis spectrophotometer (U2900, Hitachi Corporation Japan). All the estimations were performed in triplicates. Briefly, dissolved nitrate was estimated at 220 nm and concentration was estimated against known concentrations of sodium nitrate (Merck, India; Strickland and Parsons, 1972). Dissolved ammonia was estimated using potassium ferrocyanide method at 640 nm and unknown concentrations were determined against a standard of ammonium chloride (Merck, India; Liddicoat et al. 1975). The unknown concentration of o-phosphate was determined using ammonium molybdate, sulfuric acid, ascorbic acid and potassium antimonyl tartarte and measured at 885 nm. Standard curve was prepared using potassium dihydrogen o-phosphate (Strickland and Parsons, 1972). Silicate was determined using the ammonium molybdate method and determined at 610 nm against a standard curve of sodium hexafluorosilicate (Strickland and Parsons, 1972). Surface water samples were filtered through 0.22 μm 25 mm syringe filters (RanDisc, USA) and thermocatalytic combustion was undertaken at 850^{0}C in a multi-N/C 2100S analyzer (Analytik Jena AG, Germany) for estimation of dissolved carbon pools. All measurements were performed in triplicates.Samples (50 mL) for metal concentration estimation were collected daily and filtered through 0.22μm 25mm nylon syringe filter (Whatman Uniflow, UK), and fixed with ultra-pure nitric acid (Merck, Germany)to bring down to pH 2. Metals and metalloids were measured using standard (FINAR-92, Christiansburg, USA) and quantified with the multi-elemental analyser Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES), icap 7400 (Thermo Scientific, USA). During the analysis, BCR 617 and BCR 610 (EVISA, EU) Certified Reference Materials (CRMs) standards were used to check the calibrations. Subsamples of 50 mL were also collected from the studied reservoir for enumeration and identification of phytoplankton communities based on bright field microscopy.Phytoplankton taxa were identified using a drop-count method (Verlencar and Desai 2004) under a bright-field microscope (Olympus BX-53, Japan). Samples were identified at 400X magnification, and the abundance of identified genera was extrapolated to determine their equivalent abundance per litre. In addition, vegetation surrounding the reservoir including submerged vegetation was assessed visually to get an understanding of the distribution of communities. For enumeration of emerging contaminants such as microplastic, the extraction from water was undertaken following the standard methods (Masura et al. 2015)with slight modifications (Goswami et al. 2020). The organic matter was removed from water using wet peroxide oxidation (30% H2O2and ferrous solution [Fe (II); 0.05M], 20 ml each) on a hot plate at 75°C. Once the organic matter was completely removed, the density separation method was employed usingzinc chloride (ZnCl2, 933.3 g/l; density 1.6g/cm3). Subsequently, the supernatant was filtered using GF/F (0.7 µm) filter paper under a reduced vacuumto retain the MPs. The filter papers were dried in the oven and stored in sealed Petri dishes for further analysis. The numerical abundance of microplastics has been reported as pieces per L. The imaging of the encountered microplastics was undertaken using astereo-zoom microscope with imaging capabilities. As part of emerging contaminant analysis, fecal coliform bacteria were quantified from the reservoir on-site using rapid detection kit. The capacity development components involved training and building of instruments of capacity for frontline staff members and local communities to effectively assess habitat health of aquatic ecosystems including Khliehshnong water reservoir.

Results and Discussion

Rapid habitat assessment of Khliehshnong water reservoir

The sampling activity undertaken throughout the day of 23rd July, 2024 was accompanied by heavy rainfall. The surface water temperature (SWT) ranged between 20.3 to 21.8ºC based on sampling (Figure 2). The air temperature (AT) ranged between 21.5-24.3ºC on the day of sampling (Figure 2).

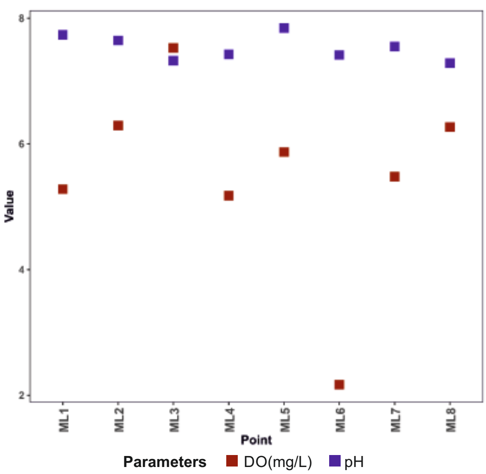


Figure 2: Profiles of surface water temperature (SWT) and air temperature (AT) in Khliehshnong water reservoir

While undertaking robust in-situ measurements in the reservoir, key parameters of habitat quality such as dissolved oxygen (DO) was meticulously measured. The DO values ranged between 2.17 to7.52 mg/L (Figure 3). The pH values ranged between 7.28-7.84 while undertaking in field assessment of the reservoir (Figure 3). The values of DO reflects healthy condition of Khliehshnong water reservoir except for one point that could be due to localized factors. The trends of DO support suitability of the habitat for diverse biological communities including fish to flourish. The pH values also supported the trends of DO and indicative of healthy habitat representing this particular reservoir.

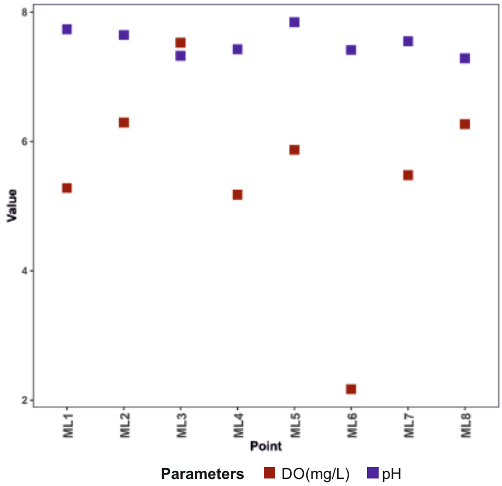


Figure 3: Profiles of DO and pH measured across the Khliehshnong water reservoir

Two water quality parameters namely, total dissolved solids (TDS) and electrical conductivity (EC), have consequences on the overall habitat quality for any aquatic ecosystem. The TDS values ranged from 107.8 to 191.6 ppm based on insitu measurements (Figure 4). For EC, the values ranged between 215.6 to 383.2 µS/cm (Figure 4).The overall trends of TDS and EC reflects that the water quality is generally good and may help shape the structures as well as functions of biological communities with overall positive consequences for Khliehshnonghabitat.

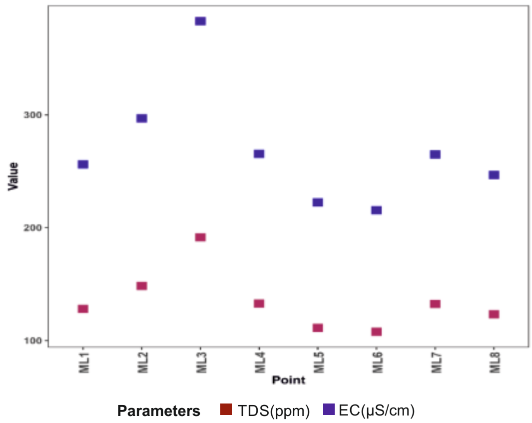


Figure 4: Profiles of TDS and EC measured in Khliehshnong water reservoir based on in situ measurements.

During habitat assessment, measurement of Secchi depth was undertaken throughout the reservoir (Figure 5). The Secchi depth values ranged from 32.5 to 43.6 cm reflecting transparency of the water column and resulting penetration of light that cansupport oxygenic photosynthetically driven primary production (e.g. different algal groups such as diatoms)with consequences for shaping structure of higher trophic levels such as resident fish population within the reservoir.

Figure5: Secchi depth measurements undertaken in Khliehshnong water reservoir

While undertaking habitat assessment of aquatic ecosystems, quantifying the forms and concentrations of dissolved nutrients provide a clear signal for unusual trend (e.g. natural variability) or impacts arising from anthropogenic disturbance. During the assessment dissolved nutrients such as ammonia, nitrate, o-phosphate and reactive silicate were measured from collected water representing Khliehshnong water reservoir. The concentration of dissolved ammonia ranged 0.03-0.36 µM; dissolved nitrate ranged from 9.30 to 16.55 µM while the o-phosphate concentrations varied between 0.64 and 1.80 µM (Figure 6). The dissolved reactive silicate concentration varied between 1.05 and 2.41µM across Khliehshnong water reservoir (Figure 6).

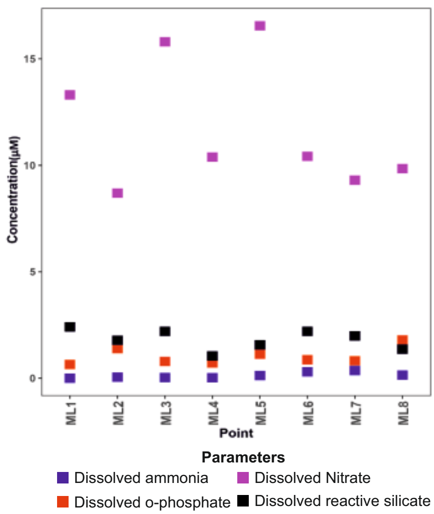


Figure 6: Profiles of dissolved ammonia, nitrate, o-phosphate and reactive silicate in Khliehshnong water reservoir

Besides dissolved nutrients, concentrations of forms of metals were quantified from the studied water reservoir. Concentration metals representing iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), cobalt (Co), nickel (Ni), lead (Pb), magnesium (Mg), potassium (K) and sodium (Na) showed spatial variability at ppb levels in Khliehshnong water reservoir (Figure 7). In particular, Fe showed concentrations ranging from 331.65 to 1087.77 ppb while magnesium concentrations varied from

25897.99 to 39830.72 ppb, along with other metals reflecting the geology of the area and possible influences of leaching of rock on the aquatic ecosystems. The observed trends based on the single time sample collection did not reflect any evidence of apparent disturbance that could alter the habitat quality of the reservoir.

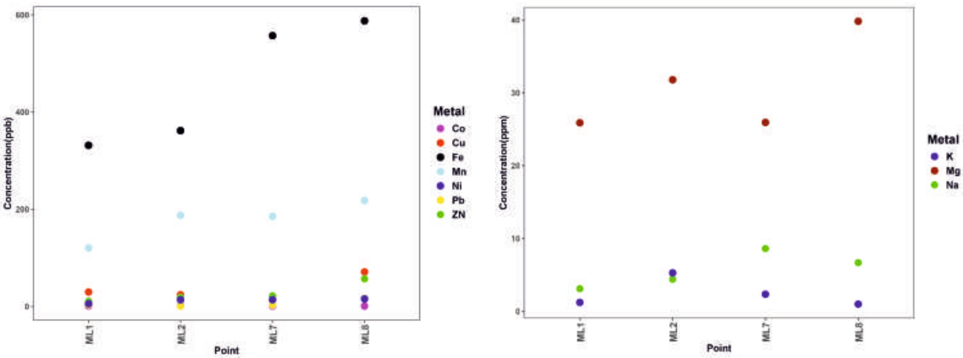


Figure 7: Concentrations of metals deduced by ICP-OES approach from Khliehshnong water reservoir

In addition to metals, concentrations of dissolved total carbon (6.62-23.29 mg/mL) as well as dissolved organic carbon (6.51-23.29 mg/L) in Khliehshnong water reservoir reflected natural pool of carbon driven by abiotic and biotic factors including the functional role of different organismal communities. The dissolved total carbon trends reflected the reservoir to be generally in good health and that the long-term effects of any disturbance were not apparent from single time sampling exercise.

To assess the presence of contaminants including emerging contaminants such as microplastics, composite water sample representing the Khliehshnong water reservoir was enumerated. There was abundance of 12 microplastic per litre from the

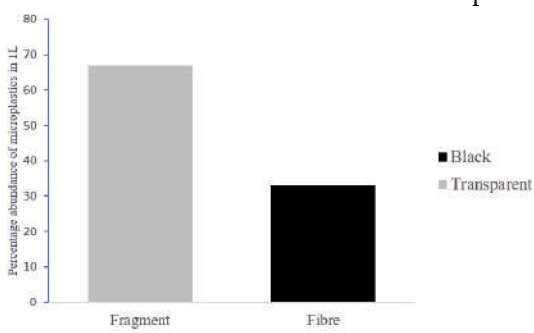


Figure 8: Shapes and colors of microplastic identified from Khliehshnong water reservoir

reservoir water. The observed microplastics were either fragment or fibre and color forms were black and transparent (Figure 8; Figure 9a and b). The presence of microplastic, albeit in low number, reflects that the effect of tourism in the Sohra region is magnifying across aquatic ecosystems including in Khliehshnong. Emerging contaminants such as microplastic can biomagnify across trophic food web and ultimately end up in fish populations. Therefore, robust sustainability approaches that will ensure no use of plastics and that the endemic fish population in the studied reservoir do not eat microplastics (as they mimic like natural food) which can ultimately lead to tissue damage, oxidative stress and changes in anti-oxidants pool.

Figure 9a: Microplastic type such as fibre was encountered in Khliehshnong water reservoir.

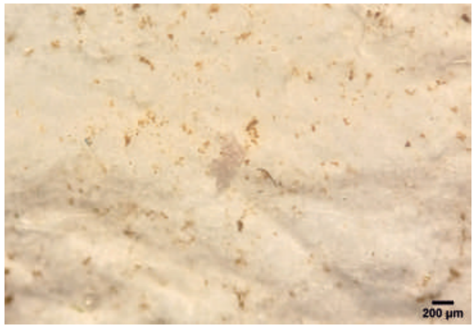


Figure 9b: Microplastic type such as fragment was encountered in Khliehshnong water reservoir.

As part of habitat assessment, contaminants that have direct relationship with human disturbance such as fecal coliform load was assessed. Ironically, in some of the sampled points with the Khliehshnong water reservoir, presence of fecal coliform bacteria (up to 103 cells per mL) were confirmed reflecting direct influences from human or possibly from release of untreated sewage (e.g. septic tank leakage) from nearby villages (e.g. Khliehshnong) located at higher elevation and possibly connected to the reservoir through downwards flow. During the sampling activities,

Figure 10: Evidences of human activities and induced signals reaching to Khliehshnong water reservoir.

visible signs of human activities such as construction of the visitor centre, disposal of kitchen waste, among others were documented (Figure 10) reflecting point sources that may have been contributing towards fecal coliform contamination.

As part of biological assessment, presence of phytoplankton and their forms represent a reliable way to understand the habitat health of aquatic ecosystems. In this rapid assessment, from water samples reflecting two points of the reservoir were enumerated for phytoplankton abundance and the values ranged between 1400-1800 cells/L. The identified phytoplankton cells were represented by genera such as Amphipleura sp., Craticula sp., Synedra sp, among diatoms (Bacillariophyta) while the green algal group (Chlorophyta) was represented by Desmodesmus sp, Cosmarium sp, and Planktosphaeria sp (Figure 11). The presence of these genera reflects overall habitat status of the reservoir to be healthy and many of these taxa serve as a source of food for resident fish population.

The reservoir also represented a habitat including submerged aquatic vegetation. The water-soil boundaries of the reservoir have a distinct presence of Ischaemum spp., Gratiola sp., Carex spp., Eriocaulon spp, Glyceria sp., among others. Some of these plant taxa have been found to be half submerged along the boundaries of reservoir as observed during the rapid assessment. The submerged and floating vegetation consisted of distinct and vast patches of Hydrilla sp, in addition to Nymphaea sp., and Chara sp,. The reservoir is also surrounded by distinct riparian vegetation. All these types of vegetation, in particular floating and submerged vegetation observed within the reservoir can act as a refuge for fish population, in addition to provide optimum habitat conditions.

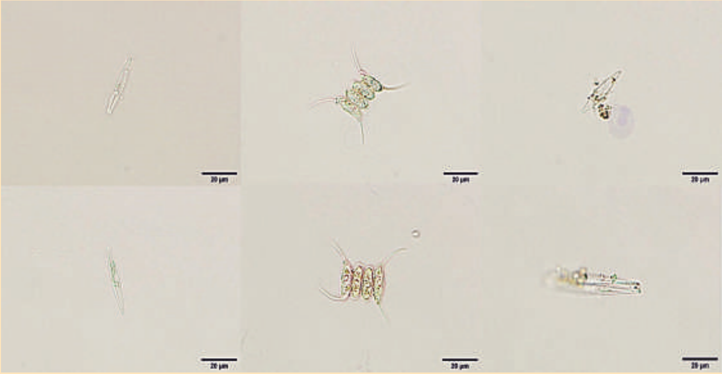


Figure 11: Representative plate of encountered phytoplankton taxa from the Khliehshnong water reservoir.

Capacity development and instrumentation support

In habitat monitoring of fragile aquatic ecosystems with endemicity, capacity development constitutes an important pillar. The capacity development in this domain involves training of frontline staff including research staff, policy makers and most importantly the indigenous as well as local communities residing in close proximity to a habitat being considered for monitoring. As part of the rapid habitat assessment of Khliehshnong water reservoir, capacity development exercise on monitoring of water quality was undertaken twice. On 23rd July (2024), five frontline staff members of the Fisheries Department, Government of Meghalaya were trained on the intricacies of sampling strategies to be undertaken during monitoring of aquatic habitats such as the Khliehshnong water reservoir (Figures 12 and 13).

Figure 12: Training of frontline staff members of the Fisheries Department in Khliehshnong water reservoir

Figure 13: Team from Fisheries Department and from the training team in Khliehshnong water reservoir

Figure 14: Capacity development of different departments under the aegis of Government of Meghalaya in habitat monitoring of aquatic ecosystems.

Subsequently, on 27th August of 2024, second capacity development activity was undertaken in Khliehshnong water reservoir involving research staff, frontline staff and policy makers representing the Fisheries Department, Government of Meghalaya, Meghalaya Biodiversity Board, Government of Meghalaya and National Biodiversity Board, Government of India. In addition, local communities were also involved as part of the capacity development training. In the second training there were participation of 10 individuals, in addition to members represented by the team of Punyasloke Bhadury. (Figure 14). Each participant learnt the fundamentals including theory of pH, dissolved oxygen, total dissolved solids, electrical conductivity and water temperature measurements for aquatic ecosystems. Each participant was meticulously trained to calibrate the hand-held probes, use of proper standards and steps to be followed during in situ measurements (Figure 15). The cost of the probes, limitations in terms of measurement accuracy and overall performance were discussed interactively with the overall participants.

Figure 15: Capacity development exercises undertaken for frontline staff and local communities in Khliehshnong water reservoir

During the capacity development-based trainings, special emphasis was laid on best practices for sampling to be followed across diverse aquatic ecosystems. Based on focused trainings, three sets of instruments comprising of digital probes for measuring pH, TDS and EC were distributed among the participants of 10 individuals. In total, 9 instruments were distributed among the participants (Figure 16). The distribution of the digital probes among the teams have led to self-instrumentation capabilities which will pave the way for monitoring of aquatic habitats including the Khliehshnong water reservoir.

Figure 16: Distribution of hand-held digital probes to frontline staff members of various different departments under the aegis of Government of Meghalaya

Overall Recommendations

Based on the rapid assessment undertaken in July, 2024 the following are broad recommendations to be kept into context during ranching and post-ranching that may enhance targeted sustainable tourism in Khliehshnong water reservoir:

(a) In the habitat assessment, water quality index (WQI) values ranged from58.29 to 83.36 reflecting 'medium to good' and 'good' quality reflecting overall good habitat status. The water reservoir is suitable for ranching of biological communities including endemic fish species

(b) In Khliehshnong water reservoir, distinct patches of submerged and floating vegetations have been encountered highlighting habitat attributes that can support refuge for many biological communities including fish population

(c) The reservoir has diverse phytoplankton communities dominated mainly by diatoms and green algae that can serve as a food for fish including ranched fish species

(d) The habitat assessment exercise did not show any visible effects of nitrogen enrichment

(e) The habitat did show initial signs of emerging contaminants such as microplastic and fecal coliform. Microplastic pollution can lead to adverse consequences for Khliehshnong water reservoir, in particular unknown physiological consequences for many endemic fish taxa. Therefore, any visitor centre development requires sensitization targeted towards tourists for sustainable practices and complete ban of use of plastics in the region and beyond.

(f) The evidence of fecal coliform bacteria indicates possible human signals. Such signals need to be continuously monitored to identify source points that can be effectively tackled using innovative strategies

(g) Khliehshnong water reservoir is generally healthy and can sustain biological communities such as fish; however, this aquatic ecosystem need to be continuously monitored for water quality and habitat quality attributes to ensure the long-term viability of sustainable tourism.

How to accurately measure critical environmental parameters?

A simplified user guide

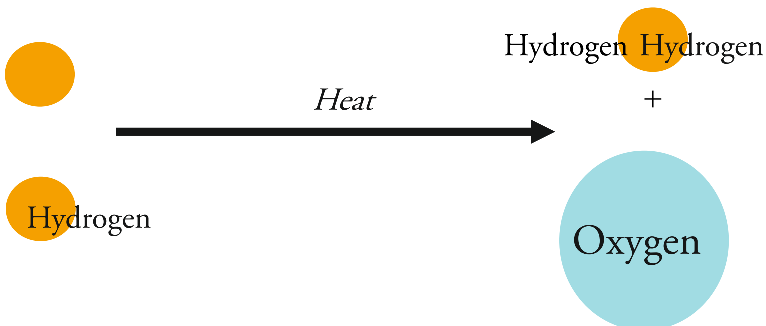
Recommendations

- Take weekly to monthly data
- Ensure measurements at similar timings throughout the monthly collection. E.g. if Site1 is sampled at 8 am, do the sampling around 8am for all months
- Note down site details, e.g., colour of water, rainfall
- Visible details and odour is important. Do the water look green? Does it smell?
- All instruments are temperature sensitive. Keep away from direct sunlight
- Remove batteries when not in use

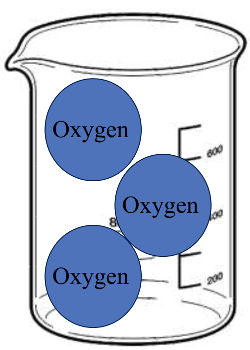
What is pH?

By definition, negative log of hydrogen ion concentration is called pH.

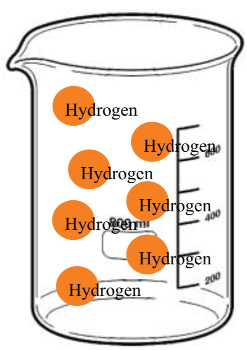
But what does that mean?



Water molecules break-up into oxygen and hydrogen when heated up

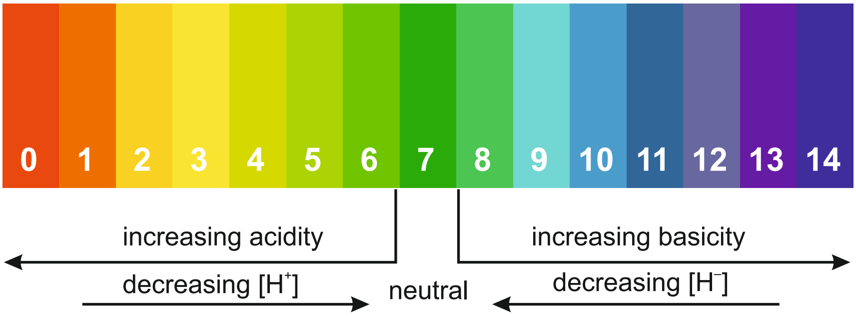


EXCESS HYDROXIDE: BASIC



EXCESS HYDROGEN: ACIDIC

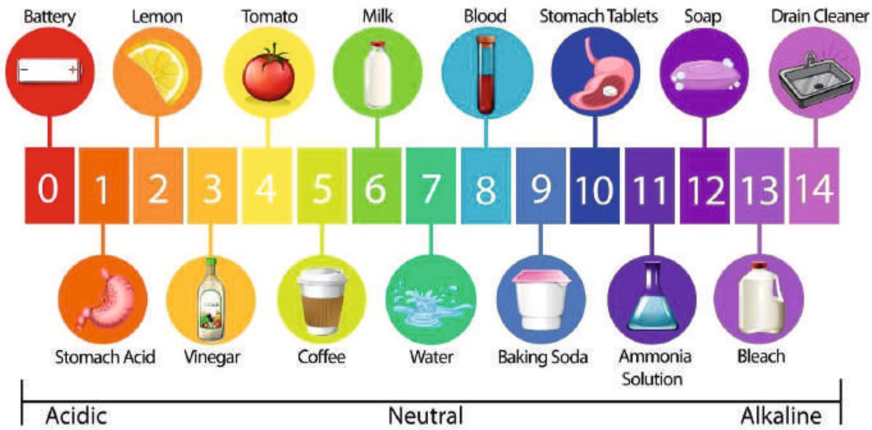
How does the pH scale look like?



$$pH = -\log [H^+]$$

pH: negative log of hydrogen ion concentration (written as [H+])

The pH Scale



Parts of pH meter

How to take the reading?

1. Go through steps for calibration
2. Power ON the probe
3. Drip the probe in water.
4. ENSURE ONLY THE blob is submerged
5. Take reading

Precautions

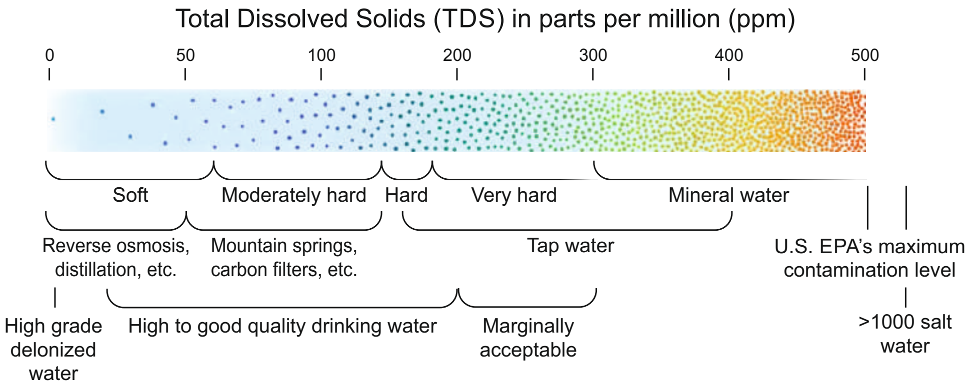
1. The probe is made of glass. Be sure to not drop it.
2. The probe is temperature sensitive. Do not allow instrument toget heated up
3. Ensure instrument is held absolutely straight during reading
4. Note down time of day during pH measurement

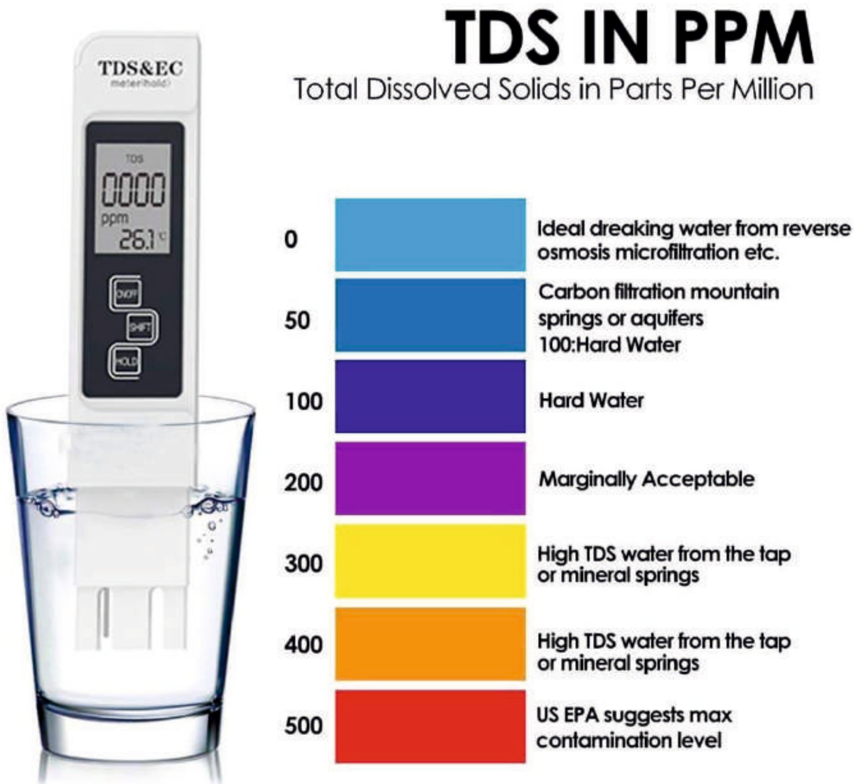
What is TDS?

Water naturally tries to dissolve items with which it comes in contact, thereby creating TDS. TDS can be comprised of dissolved minerals and metals from rocks and the earth, runoff from farming.

Please follow the same measurement method and precautions as stated for pH

Understanding TDS





Secchi Depth

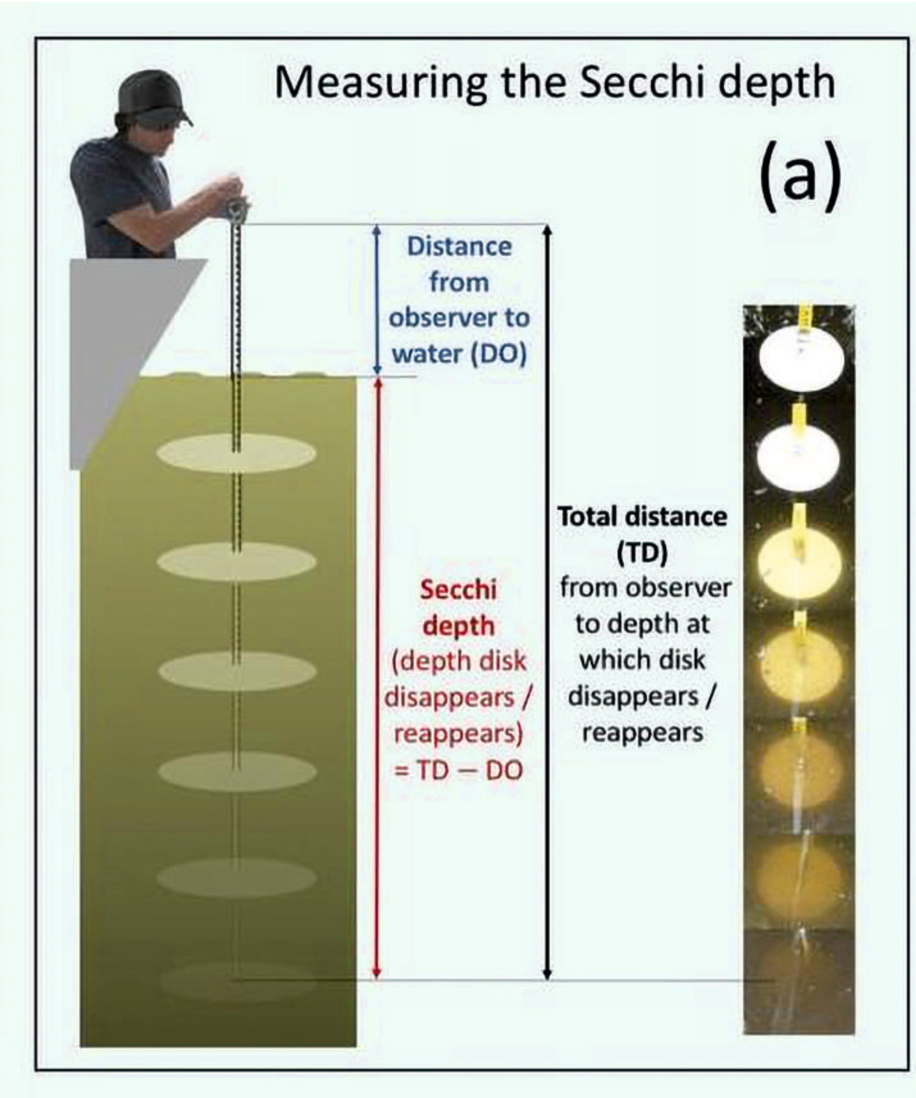
Precautions

- Keep your body straight. The disk should be lowered parallel to your arm
- Note down time of day. Peak sun readings are recommended. DO NOT TAKE READING DURING EARLY MORNING OR LATE EVENING
- Carefully note unit of measurement while taking reading (cm/m/inch)

How to measure?

Precautions

- Keep your body straight and lower the disk
- Observe carefully the depth at which the disk vanishes
- Measure distance



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