VISVESVARAYA TECHNOLOGICAL UNIVERSITY
"Jnana Sangama", Belgaum-590 014

A Dissertation Project Report on

"ASSESSMENT OF VRISHABHAVATI RIVER"

Submitted in partial fulfilment for the award of the degree of

BACHELOR OF ENGINEERING IN

CIVIL ENGINEERING

BY

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C.M.R. INSTITUTE OF TECHNOLOGY

(#32, AECS Layout, IT Park Road, Bengaluru-560 037)

Department of Civil Engineering

Certificate

This is to certify that the project work entitled **"ASSESSMENT OF VRISHBHAVATI RIVER "** has been successfully completed by Mr. MANMATH B (USN 1CR16V033), Mr. POLU PRABHATH KUMAR REDDY (USN 1CR16CV041), Mr. DASRHAN S (USN 1CR15CV023) & RAKESH P L (USN 1CR15CV068) bonafide students of CMR Institute of technology in partial fulfilment of the requirement for the award of degree of Bachelor of Engineering in Civil Engineering of the **"VISVESVARYA TECHNOLOGICAL UNIVERSITY",** Belgaum during the academic year 2019-20. It is certified that all corrections indicated for internal assessment has been incorporated in the Report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.

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2.

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<u>DECLARATION</u>

We, **Mr.Manmath B, Mr.Polu Prabhath Kumar Reddy , Mr. Darshan S** & **Mr.Rakesh P L** bonafide students of CMR Institute of Technology, Bangalore, hereby declare that dissertation entitled **"ASSESSMENT OF VRISHBHAVATI RVER "** has been carried out by us under the guidance of **Dr. Asha M Nair (HOD), Prof. Ruchir A J (Assistant Professor)**, Department of Civil Engineering, CMR Institute of Technology, Bangalore, in partial fulfilment of the requirement for the award of degree of Bachelor of Engineering in **Civil Engineering** of the Visvesvaraya Technological University, Belgaum during the academic year 2019-2020. The work done in this dissertation report is original and it has not been submitted for any other degree in any university.

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ABSTRACT

The Vrishabhavathi River is a minor river that flows through the south of the Indian city of Bangalore.It was once pristine source of drinking water. The river culminates in a reservoir named after itself Vrishabhavathi Reservoir near Bidadi. It joins Arkavathy River near Kanakapura as a tributary. The river has a basin area of 383 sq. km Currently The river is highly polluted due to pollutants from industrial, agricultural and domestic sources.[1][7] It is said to be dark, smelly and frothy due to "untreated or badly treated domestic sewage that goes into the river. In our present study we are assessing the area of land encroachment using GIS technique. The aim of this study is to assess the physicochemical parameters, extent of heavy metal content in Vrishabhavathi river water and its surrounding ground water. The perennial source of drinking water stream, today carrying large quantity of industrial, agricultural and domestic effluents (treated and untreated) from the western parts of Bangalore city. This polluted water used in agriculture due to easy availability in periurban areas causes various environmental issues in food chain contamination by heavy metals because of their potential accumulation and bioaccumulation by food chain in human health problems. Water samples of Vrishabhavathi river and its surrounding ground water collected at selected sites are subjected to comprehensive physic chemical parameters and toxic heavy metal analysis

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CONTENTS

CHAPTER 1

INTRODUCTION

The problem of environmental pollution due to toxic metals has begun a big concern now in most of the major metropolis. Many of the rivers, lakes and oceans have been contaminated by pollutants. Some of these pollutants are directly discharged by industrial plants, municipal sewage treatment plants, and heavy increase in vehicles using petroleum fuel and polluted runoff in urban and agricultural areas. The areas where no alternative source of clean water exists, peoples will adopt urban waste water for irrigation of agricultural lands to increase the production of crops. It has been reported that sewage effluents from municipal origin contain appreciable amount of major essential plant nutrients, therefore the fertility levels of the soil is improved considerably under sewage irrigation of crop fieldsThe Vrishabhavathy river originates in Bengaluru and flows south– southwest for 52 km before joining the Arkavathy river. The river once used as a major drinking water source to the population living across the river. The problem of environmental pollution due to toxic metals has begun a big concern now in most of the major parts of the river The areas where no alternative source of clean water exists, peoples will adopt urban waste water for irrigation of agricultural lands to increase the production of crops. 1400 MLD of wastewater, a third of which then drains into the river This source has been the victim of pollutants discharged by industrial, agricultural and domestic effluents. There are 21 major and 58 small scale industries will directly discharge the effluents into the river only 18% of them are found to possess effective treatment plants . In the recent years ground water pollution across Vrishabhavathi river has emerged as a severe environmental issue ,constraining its use drastically [8]. The polluted river water is extensively used for irrigating farm lands across the river on either side from Kengeri to Byramangala tank for about forty five kilometres away from the origin of the river. In this context, present study is under taken to quantify the level of heavy metals and the degree of pollution of the Vrishabhavathi river water and ground water near Bangalore city, where waste water is used for irrigation of agricultural fields.   For the present study Geographical Information System (GIS) will be used as tools for managing and analyzing the spatially distributed information. Arc GIS and QGIS are powerful softwares to analyze, visualize, update the geographical information, and create quality presentations that brings the power of interactive mapping and analysis. In our study we are planning to use QGIS

to study geographical information. And also in specific locations water and soil sampling will be done, physical and chemical characteristics of water and also certain soil characteristics will be determined and compared with the past studies.

Vrishabhavathi's banks are heavily urbanised and industrialised

CHAPTER 2

LITERATURE SURVEY

PREAMBLE

This chapter describes the literature survey of the Few of the investigations done by researchers on the use of various techniques has been demonstrated.

REVIEW ON LITERATURE

Studies on heavy metals contamination in Vrishabhavathi river water and ground water of the surrounding river

Authors: JAYADEV, PUTTAIH

Methodology: Nine water samples were collected, six sites of Vrishabhavathi river and three sites of its surrounding areas of ground water in the study area during the year 2009 in five litre distilled water washed polythene bottles. The temperature, pH , turbidity, TDS, electrical conductivity, salinity and dissolved oxygen were measured in the field at the time of sample collection using water analyzer 371 Systronics. There after 500 ml water samples collected acidified with analytical grade nitric acid to prevent the precipitation of metals. The samples were concentrated to tenfold on a water bath and analyzed for heavy metals using Atomic Absorption Spectrophotometer (GBC Avantra Version 1.31). The rest of the water sample is stored at 4o C to determine the other physicochemical parameters as per the standard methods for examination of Vrishabhavathi river and surrounding areas of ground water The results obtained were evaluated in accordance with the standards prescribed under Indian Standard Drinking water specification IS 10500:1991 of Bureau of Indian Standards.

Findings:

BOD, COD value is higher in Vrishabhavathi river water and other physicochemical are below permissible limits. The BOD value at site numbers 1,2,3,4 and 5 is in the order of 70,78,70,49,40 mg/lit. in summer and 40,43,41,25,23 mg/lit in rainy respectively and limit according to BIS standard is 3 mg/lit, the data in summer season shows higher value at all sites. COD value at site numbers 1,2,3,4 and 5 are 175,169,160,101,98 mg/lit. in summer and 125, 130, 132, 69,62 mg/lit respectively in rainy, the permissible limit is 10< mg/lit. The heavy metal concentration are higher in summer and minima in rainy season [14] due to

dilution of polluted water. The concentration of heavy metals decreases along the downstream of the river. The concentration is higher at site number 1 of upper stream. At site number 4, Pb,Ni,Cu and Cr is higher because of the addition of some more effluents from Bidadi industrial area [15]. During the present study, maximum concentration 0.15 mg/lit of Pb in site number 1,0.131 mg/lit in site 2 and further decrease along sites 3 to 5 shows the concentration decreases in downstream. The concentration is above permissible limit at site numbers 1,2and 3 respectively during summer and during rainy at site number 1 and 2. The permissible limit as per BIS standards Pb concentration is 0.05 mg /lit. These sites are in the upper stream of the river. Cr is 0.15 mg/lit at site number 1 during summer and 0.10 mg/lit in rainy, permissible limit is 0.05 mg/lit. Fe concentration 2.8, 2.5,1.4 mg/lit.in summer and 1.9,1.2,0.91 mg/lit in rainy, it is higher as per BIS standards 1.0 mg/lit. The concentration of Mn at site numbers 1 and 2 is 0.401,0.306 mg/lit in summer , 0.381 at site number 1 in rainy is observed which is above permissible limit of BIS standard 0.3 mg/lit. The physicochemical characteristics tabulated in table-3 for Vrishabhavathi river valley surrounding ground water shows that the heavy metal concentration is below BIS standards except Cr and Fe at site number 1. Total hardness is higher at site numbers 7,8,9 , is 780,710,680 mg/lit above BIS standards 600 mg/lit. Heavy metal Mn and Fe is 0.351, 1.92 mg/lit which is above permissible limit. Ca is above BIS standard at site number 9. The physicochemical parameters of Vrishabhavathi river water shows that , the water is not suitable for drinking at all sites and not suitable for irrigation in the upper stream. The pollutants present in Vrishbhavathi river water leach out in soil and contaminate ground water sources

A Case Study of Water quality Assessmemt of Vrishabhavati river ,Bidadi

Author:Vidya B R

Methodology:

To determine the physical parameters and chemical parameters of river water sample at selected points in the river.

Results and Findings:

- The present study has shown that river is much more polluted in terms of various chemical parameters such as pH, Hardness, Alkalinity, TDS, BOD, COD, DO etc, Vrishabhavathi river was above described limit.

- This result shows that the river receives very high pollutions from the surroundings. And the wastage of river highly contaminated and if the similar condition continue for the longer period, Vrishabhavathi river may soon become ecological inactive.

- The main objective of study was to know physical and chemical characteristics of river. Samples were collected and analysed for different physical and chemical parameters reveals that river is polluted due to wastage coming from Bangalore city sewage and industries. The present study shows that some of the parameters were above or below the permissible limit of wastewater standards.

- Some parameters like pH, turbidity, conductivity, COD, BOD .The pH of the river near industrial area is quite moderate. COD concentration recorded was comparatively high during pre-monsoon seasons due to high temperature and low dilution.

- The alkalinity of water body was much higher than the world and Indian standard. Hardness is quite less than the level specified in the standard. From the above conclusion it has been made evident that the industrialization in Bidadi industrial area was responsible for the present deteriorating condition. It is seen that improvement can be achieved in water quality, health, aquatic life, flora and fauna etc. with implementation of mitigation measures.

➢ At the river, colour and odour is present. Activated carbon and copper sulphate is used for the removal of colour and odour. Filtration is necessary for the sample of river water as we have obtained TSS value above 100 mg/l. TDS is above 500 mg/l in order to remove it flocculation treatment is also necessary. DO is below 4mg/l and COD is above 250 so aeration process need to be provided. The BOD value is below 4mg/l so we have to treat it by algae growth method.

Toxicity of Vrishabhavathy river water and sediment to the growth of phaseolus vulgharis (french beans)

Author: AHIPATHY M V; PUTTAIAH, E T

Methodology:

Depending on the accessibility and introduction of effluents, four sites were chosen for collection of water and sediment samples. From each site, about 10kgs of sediment soil samples were scooped out from the surface and transferred to plastic containers and surface water samples were collected in 10 litre plastic containers. Water samples were collected on alternate days whereas the sediment samples were collected only at the beginning of the experiment. French beans in packets of 100 were procured from Lalbagh nursery in Bangalore city. About 500 large sized healthy seeds were separated. As a measure of the quality of seeds with respect to germination and growth, the germination value was first determined. Higher the germination value, better the quality of seeds and more suited for the present toxicity test. The number of sprouted seeds per 100 seeds started with gives the germination value. To determine the germination value of the seeds, the seeds were soaked in demineralised bore-well water containing no organic matter for 24hrs. The seeds were then kept wet for about 72 hrs. The number of sprouted seeds was then counted and then the germination value was calculated. The germination value with the French beans used was found to be 90%. De-mineralized Bore-well water containing no heavy metals and organic matter was used for dilution of the river water. Three dilutions of 75%, 50% and 25% were prepared for each sampling station by mixing the river water with the bore-well water. In addition to this, 100% river water sample and 100% bore-well water were also used during the experiment. Good loamy soil not exposed to the polluted water was chosen for preparing

different compositions of the sediments from each site. Sediments with 75%, 50% and 25% compositions were prepared. In addition to this, 100% river sediment and 100% good loamy soil were also used. Sediment samples with the composition of 75%, 50% and 25% were placed in different plastic covers along with two covers with 100% river sediment and four covers with 100% good soil totalling up to nine covers per station. A common control used for all the stations together was 100% good loamy soil watered with 100% bore well water. The water samples, different compositions of sediment samples and the good soil were analysed for the various physico-chemical parameters such as pH, BOD, COD, total solids, total hardness, total available nitrogen, available Phosphorus, potassium, conductance and heavy metals. Three seeds were sown in each of the 37 pots (9 pots for each of the 4 stations + common control) and the date and time of sowing the seeds was noted sown. The pots were covered at the top with plastic sheet (instead of the usually used glass house) to avoid rainwater from diluting the contents in the covers.

Results and Findings:

The results of the pot experiment conducted to elucidate the effect of the Vrishabhavathy River water and sediments on the growth characteristics of French beans are presented below: Plant height: The data on plant height as influenced by water and sediment compositions at different stages of growth F-test showed that treatments, Sites and interactions were significant at all stages of growth over control except in the initial stages wherein site variations were insignificant. The statistical analysis revealed that the loamy soil treated with water from different sites of the river was found to be highly significant for plant height at all stages of growth. At initial stages of growth, treatments with different sites were at par with control but at later stages, site 4 treatments were significantly higher over the rest and control. Interactions between sites and treatments showed that loamy soil with water from site 4, gave taller plants with plant heights of 29.8cms, 39.5cms, 71.12cms and 72.81cms at different stages of growth. Among the various treatments studied with water and sediments, loamy soil with undiluted river water from different sites showed significant difference in height at all stages of growth and was statistically on par with loamy soil treated with 1:1 diluted river water. and 1:1 sediment composition treated with river water, at later stages of growth. Number of leaves: The data on number of leaves with different

compositions of river water and sediments at different stages of growth are presented in tables 3. Table 3 F-test indicated significantly higher values for treatments, sites and interactions over control at all stages except at 24DAS wherein sites did not show any significant difference from control. Loamy soil treated with river water from different sites gave significantly better number of leaves than the rest at all stages of growth. Treatments with different sites indicate that site 4 treatments were statistically significant over the rest and control at all stages except at 24 DAS when all are at par with control. Interactions show that loamy soil treated with water from site 4 surpassed the rest with values of 9.33, 13, 17.33 and 22 at the end of 14DAS, 24 DAS, 36DAS and 45DAS respectively. Leaf Area: The data on leaf area with different compositions of river water and sediments at different stages of growth are presented in tables 4. Table 4 F-test showed significant difference between various treatments, sites and interactions and control at all stages of growth. Loamy soil treated with water from different sites scored over the rest, following the trends of plant height and number of leaves. Site 4 treatments excelled in giving larger leaf area over the other sites at earlier stages of growth, but at later stages, they were on par with site 2 and site 3 treatments. Interactions indicated very clearly that loamy soil treated with water from site 4 was better in giving larger leaf area at all stages of growth. The areas recorded are 323.66cm2 , 385.5cm2 , 464.5cm2 and 541.45cm2 respectively. Number of Flowers: The data on number of flowers with different compositions of river water and sediments at different stages of growth are presented in table 5. Table 5 F-test indicated site variations to be non-significant at 36DAS, but significant for treatments and interactions at 45DAS. Statistical analysis again proved that loamy soil treated with. water from different sites was significant over others and control at all stages of growth. At 36DAS, site 1 treatments showed better results with respect to number of flowers, but were on par with site 4 treatments. At 45DAS, site 3 treatments gave more number of flowers but were on par with treatments with sites and control. Interactions showed wide variations. Number of Pods: The data on number of pods with different compositions of river water and sediments at different stages of growth are presented in table 6. Table 6 F-test indicated site treatments and interactions to be significantly better than control at 36DAS while the treatments with different sites were non-significant at 45 DAS. Among treatments, loamy soil with water from different sites followed the trends of other parameters studied at both stages. Treatments

with sites 4 and 2 were at par with site 3 at 36DAS but significant over site 1 and control. At 45DAS, site 1 treatments were significantly better than the rest of the sites and control but were statistically at par with other sites. Interactions between sites indicate that loamy soil treated with river water from site 4 far surpassed the rest. Dry Biomass: The data on dry biomass with different compositions of river water and sediments at different stages of growth are presented in tables 7. Table 7 Treatments with loamy soil with water from different sites gave maximum biomass but were on par with loamy soil treated with 3:1 and 1:1 diluted river water samples from different sites. Treatments with different sites showed site 2 to give best biomass but was found to be on par with site 4 and site 3 treatments. Interactions showed loamy soil treated with water from site 4 to be significant over the rest and control, the maximum biomass yield being 9.81gms. Heavy metal: The average heavy metal content in water and sediment is indicated in table 8. The heavy metal in the sediment is in the unavailable form as the pH is in the alkaline side (pH = 7.1 – 7.4). This prevents the heavy metals present in the insoluble combined form from being absorbed. Heavy metal content was checked only in the edible part (pods) of the plant at the end of the growth period. It was found that the heavy metal content in pods was below detectable limits.

MORPHOMETRIC ANALYSIS OF VRISHABHAVATHI WATERSHED USING REMOTE SENSING AND GIS

Author : P T Aravinda1 , H B Balakrishna2

Methodology :

➢ The Digital Elevation Model (DEM) of the study area is generated using ArcGIS software. This helps in drawing the exact boundary line of the study area. The base map is prepared using SOI toposheet number 57H/5, 57H/6, 57H/9 and 57G/12 on 1:50,000 scale. The Topomaps are scanned and projected for delineating the required features. The Digitized maps are updated with the help of satellite imagery using QGIS.

➢ The information content of this map is used as a baseline data to finalize the physical features of other thematic maps. Since the topo sheets are very old all the features like roads, railways, settlements etc are updated with the help of recent rectified and scaled satellite imageries of the area.

Spatial Variation of Surface Water Quality of Vrishabhavathi Watershed Using GIS

AUTHOR: P T Aravinda, H B Balakrishna, K C Jayaramu

METHDOLOGY: The water samples collected from 26 sampling stations was tested for physio-chemical parameters and compared with the water standards for Irrigationby Bureau of Indian Standards (BIS, 10500:2010). The locations of the water sampling sites are listed in the table 1. The major parameters namely pH, SS, DO, COD and BOD of the samples were analyzed. The Base map of the Vrishabhavathi watershed is prepared by Survey of India topographical maps 57H/5, 57H/6, 57H/9 and 57G/12 in 1:50000 scale. The Base map was georeferenced and digitized by using ArcGIS 10 for spatial analysis. Spatial interpolation technique through Inverse Distance Weighted (IDW) approach has been used in the present study to delineate the distributions of water pollutants. IDW determines cell values using a linearweighted combination set of sample points. The weight assigned is a function of the distance of an input point from the output cell location. The greater the distance, the less influence the cell has on the output value. The maps generated through GIS overlay analysis shows spatial variation of sensitive water quality parameters in the watershed.

RESULTS:

The spatial and attribute database generated for the water samples parameters were integrated for the generation of spatial variation of maps of sensitive parameters like PH , DO, SS, BOD and COD. Based on these spatial variation maps of sensitive water quality parameters, an integrated water quality map of the Vrishabhavthi watershed was prepared using GIS. This integrated water quality maps helps us to know the existing water quality conditions in the watershed.

 pH

pH is the one of the important parameters of the water and determines the acidic and alkaline nature of water. The good quality of water having the pH in the range of 7 to 8.3. In the present study during pre monsoon pH is rangingbetween 6.2 to 7.9 and during post monsoon

pH is ranging between 6.5 to 8.1. The spatial map of pH was prepared for pre monsoon and post monsoon

Suspended Solids

 (SS) The suspended solids was classified in to three ranges (425 mg/l for pre monsoon and 500 mg/l for post monsoon) and based on these ranges the spatial variation map of Suspended solids has been prepared . It is clear from the map that except in central part of the watershed has acceptable range of Suspended solids.

Dissolved Oxygen (DO)

 DO is the most important sensitive parameter for assessing the water quality and reflects the physical and biological process. Dissolved oxygen is needed for living organism to maintain biological process. The Dissolved oxygen was classified in to three ranges (3.5 mg/l for pre monsoon and < 2.5 mg/l, 2.5-5 mg/l and > 5 mg/l for post monsoon) and based on these ranges the spatial variation map of Dissolved oxygen has been prepared In the present study the rural area of water having acceptable range of DO

Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand is defined as the amount of oxygen required by bacteria in stabilizing the decomposable organic matter. BOD gives the clear picture about the extent of surface water pollution. In the present study BOD was classified in to three ranges (200 mg/l for pre monsoon and 150 mg/l for post monsoon) and based on these ranges the spatial variation map of BOD has been prepared

Chemical Oxygen Demand (COD)

 COD determine the amount of organicpollutants found in surface water (e.g. lakes and rivers) or wastewater, making COD a useful measure of water quality.The COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic particles.In the present study BOD was classified in to three ranges (< 250 mg/l, 250-500 mg/l and >500 mg/l for pre monsoon and 400 mg/l for post monsoon) and based on these ranges the spatial variation map of COD has been prepared

Integration of Data Using GIS In the integrated GIS analysis, all the spatial variation maps of sensitive water quality parameters such as pH, Suspended Solids, DO, COD and BOD were integrated into a weighted index overlay process. In the present study, the criterion table with suitable ranks and weightages adopted for the sensitive water quality parameters map. The integrated water quality map of Vrishabhavathi Watershed was prepared for premonsoon and postmonsoonare The integrated map shows the clearpicture about Acceptable, Poor and Very poor zones in the study area. From the integrated analysis, acceptable range of water quality prevails over the rural area of the watershed and the rest of the area has Poor and Very poor condition.

Methodology:

Land encroachment

- **Land encroachment studies in QGIS in a defined boundary**

- **Collection of map from Survey Of India or Google Earth**

- **Comparison of the present scenario with the past findings**

Water quality

- **Sampling at minimum at 10 locations**

- **Determining the physical characteristics like PH , colour , odour**

- **Determining the chemical charcteristics like COD , BOD, DO**

Soil and Vegetation

- **Effects on the soil present in the catchment area due the contaminants present in waste water**

GIS SOFTWARES

GOOGLE EARTH

Google Earth is a computer program that renders a 3D representation of Earth based primarily on satellite imagery. The program maps the Earth by superimposing satellite images, aerial photography, and GIS data onto a 3D globe, allowing users to see cities and landscapes from various angles. Users can explore the globe by entering addresses and coordinates, or by using a keyboard or mouse. The program can also be downloaded on a smartphone or tablet, using a touch screen or stylus to navigate. Users may use the program to add their own data using Keyhole Markup Language and upload them through various sources, such as forums or blogs. Google Earth is able to show various kinds of images overlaid on the surface of the earth and is also a Web Map Service client. Recently Google has revealed that Google Earth now covers more than 98 percent of the world, and has captured 10 million miles of Street View imagery, a distance that could circle the globe more than 400 times. In addition to Earth navigation, Google Earth provides a series of other tools through the desktop application. Additional globes for the Moon and Mars are available, as well as a tool for viewing the night sky. A flight simulator game is also included. Other features allow users to view photos from various places uploaded to Panoramio, information provided by Wikipedia on some locations, and Street View imagery. The web-based version of Google Earth also includes Voyager, a feature that periodically adds in-program tours, often presented by scientists and documentarians.

Google Earth has been viewed by some as a threat to privacy and national security, leading to the program being banned in multiple countries. Some countries have requested that certain areas be obscure3D imagery

QGIS

Until 2013 known as Quantum GIS is a free and open-source cross-platform desktop geographic information system (GIS) application that supports viewing, editing, and analysis of geospatial data.

Functionality

QGIS functions as geographic information system (GIS) software, allowing users to analyze and edit spatial information, in addition to composing and exporting graphical maps. QGIS supports both raster and vector layers; vector data is stored as either point, line, or polygon features. Multiple formats of raster images are supported, and the software can georeference images. QGIS supports shapefiles, coverages, personal geodatabases, dxf, MapInfo, PostGIS, and other formats.Web services, including Web Map Service and Web Feature Service, are also supported to allow use of data from external sources.

QGIS integrates with other open-source GIS packages, including PostGIS, GRASS GIS, and MapServer. Plugins written in Python or C++ extend QGIS's capabilities. Plugins can geocode using the Google Geocoding API, perform geoprocessing functions similar to those of the standartoolsfound in ArcGIS, and interface
with PostgreSQL/PostGIS, SpatiaLite and MySQL databases. QGIS tab is shown below in the figure
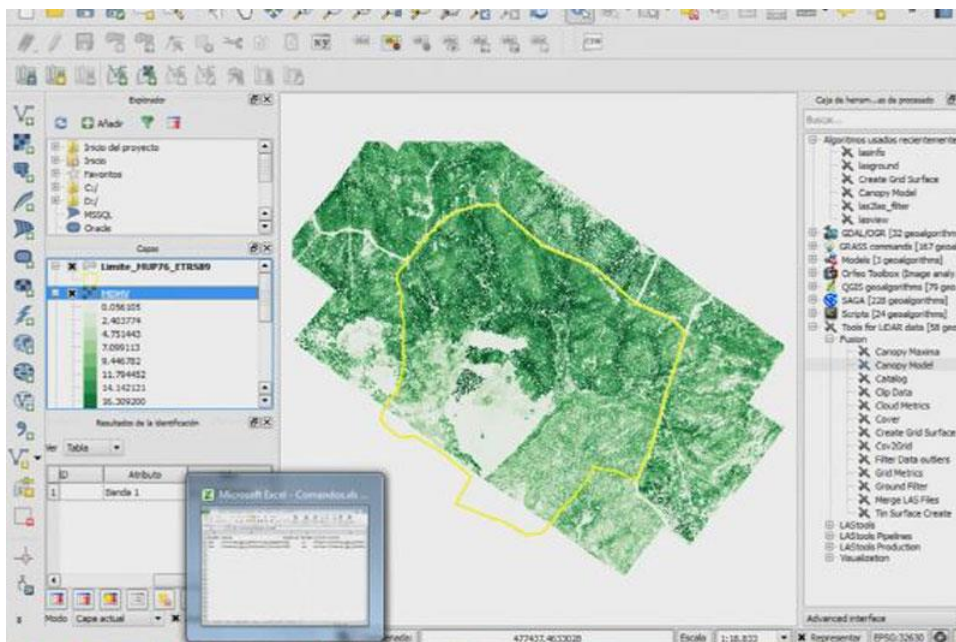
Tests conducted on water

PHYSICAL TESTS:

Commonly conducted water quality tests include:

Temperature testing

Testing the temperature helps determine the rate of biochemical reaction in an aquatic environment and indeed whether they are able to occur at all. If the water temperature is too elevated, this can limit the water's ability to hold oxygen and decrease organisms' capacity to resist particular pollutants.

pH testing

Measures the acidity of water. Most aquatic organisms are only able to survive within a pH range of 6 to 8.

Chloride test

Chloride is usually present in fresh and salt water. However, its levels can be exacerbated as a result of minerals dissolving and industrial pollution

Salinity testing

Measures the total of all non-carbonate salts dissolved in water. Measuring groundwater salinity indicates how salty your topsoil may become if the watertable rises.

Dissolved Oxygen Test

Measures the amount of oxygen dissolved in water. Without this, aquatic life is unable to conduct cellular respiration and is thus a key indicator of water health.

Turbidity test

Measures the amount of particulate matter that is suspended in the water, or more simply, how clear the water is. If high levels of turbidity are present, photosynthesis is affected as light is unable to penetrate, increasing water temperature.

Nitrate and Phosphate

The presence of these essential nutrients is a good indicator of strong plant life. However, the addition of artificial nitrates and phosphates through detergents, fertilisers or sewage can be harmful and result in eutrophication, generally in the form of unwanted algal blooms.

Pesticides

We measure whether any pesticides are present and their concentration levels.

Redox

The measurement of the reduction-oxidisation potential of a solution, which indicates the electron activity. Micro-organism growth is highly dependent on these levels.

Electrical conductivity

Estimates the total amount of solids dissolved in the water. This can be a good indicator of the level of salinity.

Metals

Testing that indicates the presence of a suite of metals which are not naturally occurring in water. Heavy metals (Aluminium, Antimony, Arsenic, Beryllium, Bismuth, Copper, Cadmium, Lead, Mercury, Nickel, Uranium, Tin, Vanadium and Zinc) can find their way into water bodies through natural processes or human activities such as mining, processing of minerals, use of metals as containers and transportation through metallic pipelines. Heavy metals are known to harm kidneys, liver, nervous system and bone structure.

Lead poisoning in humans can cause problems in synthesis of haemoglobin, kidneys, gastrointestinal tract, joints and reproductive systems and acute or chronic damage to the nervous system. Lead can also cause osteoporosis and weaken bones because it starts replacing Calcium in the bones.

Long-term exposure of cadmium leads to renal dysfunction. High exposure can least to lung cancer and osteodystrophy. Nickel has numerous reported mechanisms of toxicity including redox – cycling and inhibition of DNA repair as well as exhibiting allergic effects.

Exposure to mercury can lead to tremors, gingivitis and other psychological changes with spontaneous absorption and congenital malformation. Mono methyl mercury causes damage to the brain and the central nervous system, congenital malformations and development changes in young children. Vanadium has toxic effects on the liver, kidney, nervous and cardiovascular systems and blood forming organs.

Other tests

Petroleum hydrocarbons (TRH), Monocyclic Aromatic Hydrocarbons (BTEX) and Poly Aromatic Hydrocarbons (PAHs, including benzo (a) pyrene)

The state of the water can change frequently as a result of:

- Soil entering the water through events such as erosion, land clearing and overgrazing.

- Chemicals entering the water through fertilisers, pesticides and leeching

- Pollution entering the water from the refuse of factories, sewage systems, mines and service stations

- Rubbish disposal (both small scale and from landfill)

Regular water testing can be helpful over a long period of time to monitor any changes that occur in water quality. If this occurs, it is essential that the monitoring occurs at fixed intervals from the same point. However, it can also be a good idea to conduct water testing in response to an unexpected event such as a chemical spill.

Groundwater is one of the nation's most important natural resources, however, due to a combination of different human activities the quality of this water can be placed at risk, potentially rendering it unsuitable for use. Groundwater contamination is the result of either point source leakage or diffuse sources from leaking underground storage tank, ill-managed waste disposal site or the infiltration of pesticides and nutrients leaching down through the soil to the water table.

Once groundwater is contaminated, remediation can be a slow and costly process, consequently, ensuring good practice is the best way of protecting groundwater quality.

1. Groundwater Quality Assessment

Cost effective system design to monitoring well installation and maintenance, including aquifer analyses and characterisation. This will identify the likely location/direction of any existing or potentially contaminated groundwater plume flow, assess and describe the source, type, extent and level of contamination (if present) and provide an assessment of groundwater contamination.

2. Water Supply Investigations

Typical water quality parameters:

- pH

- Temperature

- Dissolved oxygen

- Electrical conductivity (EC)

- Biological oxygen demand (BOD)

- Heavy metals

- Poly-aromatic hydrocarbons (PAHs)

- Total Recoverable Hydrocarbons (TRH)

- Benzene, Toluene, Ethylbenzene and Xylene (BTEX)

- Faecal Coliforms

- Enterococci

CHEMICAL TESTS:

Test formats

Typical low-tech, portable, field test methods for chemical water quality monitoring fall into three categories:

- *Test strips* – These are small, single-use strips that change color to indicate the concentration of a specific chemical. Depending on the particular test, the user "activates" the paper or plastic strip by dipping it into the water sample and swishing it around, or by holding the strip in a stream of water. After waiting for a short time, the user compares the test strip color with a color chart to read the concentration of the

chemical. These kits are extremely simple, but they are less accurate than other methods, especially if users don't follow the instructions.

- *Color disk kits* – Color disk test kits are available for a wide range of chemical tests. In a typical set-up, the user adds a powder packet or a few drops of a liquid reagent to a water sample in a reusable plastic tube. The user then places the sample tube in a small plastic viewing box. This viewing box contains a plastic disk with a color gradient printed on it. The user rotates the color disk to find the part that best matches the color of the sample, and then reads the concentration of the chemical from the disk. Color disk kits typically have multiple steps and often include prescribed wait times, so they're a little more complicated and costly, but generally more accurate.

- *Hand-held digital instruments* – Lightweight and portable digital meters, colorimeters, and photometers are available for water testing. They provide the most accurate results of these three testing methods, but they are also more expensive and delicate than the previous options. These instruments require batteries and calibration. While digital instruments are helpful to field technicians and are an essential part of any continuous or remote monitoring network, they are unlikely to be suitable for "citizen science" or crowdsourced water quality testing.

Chemical water quality parameters

Having identified various test formats, the next question is: What do we test for? UNICEF recommends prioritizing fluoride, arsenic, and nitrate for chemical monitoring. In areas where the earth is naturally rich in minerals that contain fluorine and arsenic, levels in well water can be high enough that chronic exposure is dangerous to human health.[1]

How can we test for these elements?

- Fluoride: At least one color disk test kit is available for fluoride. However, portable digital colorimeters are often preferred because of concerns over accuracy. Ackvo Caddisfly, a testing system, recently described a colorimetric fluoride test that can be read by a smartphone app.

- Arsenic: Portable field testing options for arsenic are limited; this contaminant is best measured in a laboratory. Commercially available test kits do exist, but they are relatively complex and require several steps. Although the arsenic concentrations "measured" with these test kits may be inaccurate, the kits do detect arsenic in nearly all samples greater than 100 micrograms per liter (ug/L), as well as in most samples in the 50-99 ug/L range. UNICEF has therefore recommended reporting arsenic monitoring results from these portable tests as "present" or "absent" using a reference concentration of 50 ug/L—the drinking water standard in many countries that are affected by natural arsenic contamination.

- Nitrate: Both test strips and color disk test kits are available for nitrate testing. Nitrate can also be measured with a digital meter. High levels of nutrients are associated with

agricultural pollution from fertilizers (nitrogen and phosphorous) and animal waste (nitrogen). Latrines, sewage, landfills, and industrial pollution can also contribute nitrogen. Monitoring for nitrate is a simple way to assess the impacts of agricultural and human waste on water quality.

Resources permitting, UNICEF suggests adding three more chemical parameters to monitoring programs: the naturally-occurring metals iron and manganese, and the overall total dissolved solids (TDS). All three can cause taste and odor problems that might motivate consumers to seek out more appealing – and potentially unsafe – water sources.

- Iron and Manganese: Both test strips and color disk tests are available for these two metals, which may also be measured using portable, digital instruments. Field testing with digital equipment is considered reliable for iron and manganese.

- TDS: TDS includes a mixture of inorganic salts, mostly sodium, chloride, potassium, calcium, and magnesium. Rather than testing the particular components, TDS is monitored by measuring the conductivity of the water with a digital meter. There is no test strip or color disk kit that can be used here, although at least one conductivity meter interfaces with a smartphone.

In chlorinated distribution systems, it is important to monitor two more chemical parameters: pH and chlorine residual.

- pH: pH test strips and color disk tests are widely available. More expensive, higher-tech options include electrode-based pH meters. pH is a measure of hydrogen ion activity, which means that it tells us how acidic or basic the water is. pH is not a pollutant, but it is a chemical master variable. It affects the behavior of other chemical constituents, including the effectiveness of residual chlorine against microbial contamination. Sudden changes in pH can also reveal treatment plant failures or pollution events in natural water bodies (for example, illegal industrial discharge).

- Chlorine: There are many easy ways to test residual chlorine, including test strips, color disks, and even kits designed for testing swimming pools. Portable digital meters also exist that can provide reliable, quantitative measurements.

Depending on local conditions and on the focus of a water quality monitoring project, more chemical tests can be added. One might test for alkalinity or hardness, (including calcium, magnesium, etc.; field kits are available), chloride (an indicator of road salt or seawater intrusion; test kits exist), dissolved oxygen,[2] organic carbon levels (BOD, COD, TOC), agrochemicals (specific pesticides or fertilizers), or mining/industrial contaminants (e.g., polychlorinated biphenyls, cyanide). Finally, heavy metals like lead, mercury, copper, chromium, etc. are often of local interest.

Test procedures

BIOCHEMICAL OXYGEN DEMAND (3 DAYS, 27°C)

Method **:** Bottle incubation for 3 days

Apparatus

a. BOD bottles, 300 mL, narrow mouth, flared lip, with tapered and pointed ground glass stoppers.

b. Air incubator or water bath, thermostatically controlled at $27 \pm 1°C$. Light entry must be prevented in order to avoid photosynthetic oxygen production

c. Accessories: plastic tube, screw-pin and a 5-10 L water container.

Reagents

a. Phosphate buffer solution. Dissolve 8.5 g KH_2PO_4, 21.75 g K_2HPO_4, 33.4 g $Na_2HPO_4.7H_2O$ and 1.7 g NH_4Cl in 1L distilled water.

b. Magnesium sulphate solution. Dissolve 22.5 g $MgSO_4.7H_2O$ in 1L distilled water.

c. Calcium chloride solution. Dissolve 27.5 g $CaCl_2$ in 1L distilled water.

d. Ferric chloride solution. Dissolve 0.25 g $FeCl_3.6H_2O$ in 1L distilled water.

e. Acid and alkali solution. 1N NaOH and 1N H_2SO_4. Use for neutralising samples.

f. Glucose-glutamic acid solution (prepare fresh). Dissolve 150 mg dry reagent grade glucose and 150 mg dry reagent grade glutamic acid in 1L distilled water

g. Sample dilution water. Add 1 mL each of phosphate buffer, $MgSO_4$, $CaCl_2$ and $FeCl_3$ solutions per litre distilled water.

Procedure

a. Prepare required amount of dilution water at the rate of 1000 to 1200 mL per sample per dilution. Bring the diluted water temperature to 27°C. Saturate with air by shaking in a partially filled bottle, by bubbling with organic free filtered air or by storing in cotton-plugged bottles for a day.

b. Some samples do not contain sufficient microbial population (for example, some industrial wastes, high temperature wastes, or wastes with extreme pH values). For such wastes, the dilution water is seeded using effluent from a biological treatment system processing the waste. Where this is not available, use supernatant from domestic wastewater after settling for at least 1 h but not more than 36 h. Seed from a surface water body receiving the waste may also be suitable. Add enough seed volume such that the DO uptake of the seeded dilution water is between 0.6 and 1.0 mg/L. For domestic wastewater seed, usually 4 to 6 mL seed / L of dilution water is required. Surface water samples usually do not require seeding.

c. Dilution of sample. Dilutions must result in a sample with a residual DO (after 3 days of incubation) of at least 1 mg/L and a DO uptake of at least 2 mgl/L. Make several dilutions using the Table and experience with the particular sample source. Polluted surface waters may have 5 to 25 mg/L BOD
For preparing dilution in graduated cylinders, siphon dilution water, seeded if necessary, into a 1 to 2 L capacity cylinder. Siphoning should always be done slowly without bubbling, use a screw-pin on the tube to regulate the flow. Keep the tip of the tube just below the water surface as it rises. Fill cylinder half full, add desired quantity of sample and dilute to appropriate level, mix with plunger type mixing rod. Siphon mixed diluted sample in three BOD bottles, stopper without entraining any air. Determine initial DO (method 1.9) on one bottle and incubate the other two at 27°C. Determine final DO (method 1.9) in duplicate after 3days.

For direct pipetting, siphon the desired sample volume to individual bottles and fill with enough dilution water. Complete the test as in the earlier case.

d. Dilution water blank. Find the DO consumption of unseeded dilution water by determining initial and final DO as in c above. It should not be more than 0.2 mg/L

e. Seed control. Determine the DO uptake by seeding material according to the procedure in *c* above.

Calculation

a. When dilution water is not seeded:

$$\text{BOD}_{3,27}, \text{mg.l}^{-1} = \frac{D_0 - D_T}{P}$$

b. When dilution water is seeded:

$$\text{BOD}_{3,27}, \text{mg.l}^{-1} = \frac{(D_0 - D_T) - f \times (B_0 - B_T)}{P}$$

where:

D_0 = DO of diluted sample initially, mg/L

D_T = DO of diluted sample after 3 day incubation at 27°C, mg/L

P   = decimal volumetric fraction of sample used

B_0 = DO of seed control initially, mg/L

B_T = DO of seed control after incubation, mg/L f   = ratio of %seed in diluted sample to %seed in seed control

CHEMICAL OXYGEN DEMAND

Method: Open reflux

Apparatus

a. Reflux flasks, consisting of 250 mL flask with flat bottom and with 24/29 ground glass neck

b. Condensers, 24/29 and 30 cm jacket Leibig or equivalent with 24/29 ground glass joint, or air cooled condensers, 60 cm long, 18 mm diameter, 24/29 ground glass joint.

c. Hot plate or gas burner having sufficient heating surface.

Reagent

a. Standard potassium dichromate solution, 0.0417M (0.25N): Dissolve 12.259 g $K_2Cr_2O_7$, primary standard grade, previously dried at 103^oC for 2 hours, in distilled water and dilute to 1L.

b. Sulphuric acid reagent: Add 5.5g Ag_2SO_4 technical or reagent grade, per kg of conc. H_2SO_4, keep for a day or two to dissolve.

c. Ferroin indicator solution: Dissolve 1.485g 1, 10-phenanthroline monohydrate and 695 mg $FeSO_4.7H_2O$ in distilled water and dilute to 100 mL. Commercial preparation may also be available.

d. Standard ferrous ammonium sulphate (FAS), titrant, 0.25M: Dissolve 98g Fe $(NH_4)_2$ $(SO_4)_2.6H_2O$ in distilled water, add 20 mL conc. H_2SO_4, cool and dilute to 1L, standardise daily as follows.

e. Standardisation: Dilute 10 mL standard $K_2Cr_2O_7$ to about 100 mL, add 30 mL conc H_2SO_4, cool. Add 2 drops of ferroin indicator and titrate with FAS.

f. Molarity FAS = Volume of 0.0417M K^{2Cr2O7}, mL $\times 0.25$ Volume of FAS used, mL

g. Mercuric Sulphate, $HgSO_4$, powder

h. Potassium hydrogen phthalate (KHP) standard: Lightly crush and dry potassium hydrogen phthalate ($HOOCC_6H_4COOK$), at 120^oC, cool in desiccator, weigh 425 mg in distilled water and dilute to 1L. This solution has a theoretical COD of 500 $\mu gO_2/mL$, stable for 3 months in refrigerator.

Procedure

a. Add 50 mL of sample or an aliquot diluted to 50 mL with distilled water in a 500 mL refluxing flask. Add 1g $HgSO_4$, few glass beads, and 5 mL sulphuric acid reagent, mix, cool. Add 25 mL of 0.0417M $K_2Cr_2O_7$ solution, mix. Connect the flask to the condenserand turn on cooling water, add additional 70 mL of sulphuric acid reagent through open end of condenser, with swirling and mixing. Reflux for 2 hours; cool, wash down condenser with distilled water to double the volume of contents, cool.

b. Add 2 drops of Ferroin indicator, titrate with FAS the remaining potassium dichromate, until a colour change from bluish green to reddish brown. Also reflux and titrate a distilled water blank with reagents.

c. Use standard 0.00417M $K_2Cr_2O_7$, and 0.025M FAS, when analysing very low COD samples.
d. Evaluate the technique and reagents by conducting the test on potassium hydrogen phthalate solution.
e. Do not add grease at the Leibig jacket to prevent jamming, use water instead.

Calculation

$$\text{COD, mgO2/l} = \frac{(A - B) \times M \times 8000 \text{ ml}}{\text{sample}}$$

where:
  A   = FAS used for blank, mL
  B   = FAS used for sample, mL
 M   = Molarity of FAS

DISSOLVED OXYGEN

Apparatus

a. DO sampler, for collection of undisturbed samples from surface waters.

b. BOD bottles, 300 mL , narrow mouth, flared lip, with tapered and pointed ground glass stoppers.

c. A siphon tube, for laboratory use.

Reagents

a. Manganous sulphate solution. Dissolve 480 g $MnSO_4$.$4H_2O$, 400 g $MnSO_4.2H_2O$ or 364 g $MnSO_4.H_2O$ in distilled water, filter and dilute to IL.

b. Alkali-iodide-azide reagent. Dissolve 500 g NaOH (or 700 g KOH) and 135 g NaI (or 150 g KI) in distilled water and dilute to IL. Add 10 g NaN_3 dissolved in 40 mL distilled water. c. Sulphuric acid, conc

d. Starch indicator. Dissolve 2 g laboratory grade soluble starch and 0.2 g salicylic acid as a preservative, in 100 mL hot distilled water.

e.   Standard sodium thiosulphate titrant, 0.025M (0.025N). Dissolve 6.205 g $Na_2S_2O_3.5H_2O$ in distilled water. Add 1.5 mL 6NNaOH or 0.4 g solid NaOH and dilute to 1000 mL . Standardise with bi-iodate solution.

f.   Standard potassium bi-iodate solution, 0.0021M (0.0126N), Dissolve 812.4 mg $KH(IO_3)_2$ in distilled water and dilute to 1000 mL .

Standardisation: Take 100 to 150 mL distilled water in an Erlenmeyer flask. Add approximately 2g KI, dissolve. Add 1 mL 6N H_2SO_4 or a few drops of conc H_2SO_4 and 20 mL bi-iodate solution. Dilute to 200 mL and titrate liberated iodine with thiosulphate titrant to a pale straw colour. Add a few drops of starch indicator. Continue titration to first disappearance of blue colour. Calculate molarity, M of thiosulphate as:

$$M = \frac{20 \times 0.0126}{V}$$

where:

V =   mL of thiosulphate used

Procedure

a. Drain any liquid in the flared lip of the BOD bottle containing the sample.
b. Remove stopper and add 1 mL of $MnSO_4$ followed by 1 mL alkali-iodide-azide reagent. Hold the pipette tip just below the liquid surface touching the side of the bottle. Wash the pipette before returning to the reagent bottles. Stopper carefully to exclude air bubbles. Mix by inverting the bottle a few times. Allow the brown manganese hydroxide floc (white floc indicates absence of DO) to settle approximately to half the bottle volume, add 1.0 mL conc H_2SO_4 and re-stopper. Mix by inverting several times until dissolution is complete.
c. Titrate 201 mL with standard $Na_2S_2O_3$ as for standardisation procedure described above.

Calculation

$$mgDO/L = V \times M$$

PH

Method: POTENTIOMETRIC

a. Apparatus : pH meter with temperature compensating device, accurate and reproducible to 0.1 pH

unit with a range of 0 to 14.

b. Reference electrode preferably with quartz liquid junction. Follow manufacturer's instructions on use and care of the reference electrode. Refill non-sealed electrodes with correct electrolyte to proper level and make sure junction is properly wetted.

c. Glass electrode. Follow manufacturer's instructions on use and care of electrode.

Reagents

a. Potassium hydrogen phthalate buffer, 0.05M, pH 4.00. Dissolve 10.12 g $KHC_8H_4O_4$ (potassium hydrogen phthalate) in 1000 mL freshly boiled and cooled distilled water

b. 0.025M Potassium dihydrogen phosphate + 0.025M disodium hydrogen phosphate buffer, pH 6.86. Dissolve 3.387 g KH_2PO_4 + 3.533 g Na_2HPO_4 in 1000 mL freshly boiled and cooled distilled water

c. *0.01M sodium borate decahydrate (borax buffer), pH = 9.18.* Dissolve 3.80 g $Na_2B_4O_7.10H_2O$ in 1000 mL freshly boiled and cooled distilled water.

Procedure

a. Remove electrodes from storage solution, rinse, blot dry with soft tissue, place in initial buffer solution and standardise pH meter according to manufacturer's instructions.

b. Remove electrodes from the first buffer, rinse thoroughly with distilled water, blot dry and immerse in second buffer preferably of pH within 2 pH units of the pH of the sample. Read pH, which should be within 0.1 unit of the pH of the second buffer.

c. Determine pH of the sample using the same procedure as in (b) after establishing equilibrium between electrodes and sample. For buffered samples this can be done by dipping the electrode into a portion of the sample for 1 min. Blot dry, immerse in a fresh portion of the same sample, and read pH.

d. With dilute poorly buffered solutions, equilibrate electrodes by immersing in three or four successive portions of the sample. Take a fresh sample to measure pH.

ALKALINITY, PHENOLPHTHALEIN

Method : TITRIMETRIC TO PH=8.3 (PHENOLPHTHALEIN)

Apparatus:.Standard laboratory glassware such as burettes, volumetric flasks, conical flasks and beakers.

Reagents

a. *Standard sodium carbonate, approximately 0.05N.* Dry 3 to 5g sodium carbonate, Na_2CO_3, at 250°C for 4h and cool in a desiccator. Accurately weigh 2.5±0.2g to the nearest mg, dissolve in distilled water and make to 1L.

b. *Standard H_2SO_4, approximately 0.1N.* Dilute 2.8 mL conc. sulphuric acid to 1L. Standardise against 40.00 mL $0.05N$ Na_2CO_3 with about 60 mL distilled water, in a beaker by titrating potentiometrically to pH 5. Lift out electrodes, rinse into the same beaker and boil gently for 3 to 5 min under a watch glass cover. Cool to room temperature, rinse cover glass into beaker and finish titration to pH 4.3. Calculate normality of sulphuric acid:

$$\text{Normality}, N = \frac{A \times B}{53.00 \times C}$$

where:

  A   = g Na_2CO_3 weighed into the 1L-flask for the Na_2CO_3 standard (see a.)

  B   = mL Na_2CO_3 solution taken for standardisation titration

  C   = mL acid used in standardisation titration

c. Standard sulphuric acid, 0.02N. Dilute the approximate 0.1N solution to 1L. Calculate volume to be diluted as:

$$\text{mL volume} = \frac{20}{N}$$

where:

N   = exact normality of the approximate 0.1N solution.

d. Phenolphthalein indicator solution, alcoholic, pH 8.3. Dissolve 5 g phenolphthalein in 500 mL 95% ethyl alcohol. Add 500 mL distilled water

Calculations: Phenolphthalein alkalinity, mg $CaCO_3/L = \dfrac{A \times N \times 50000}{\text{mL sample}}$
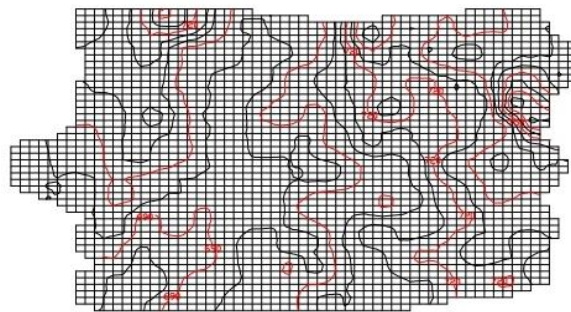
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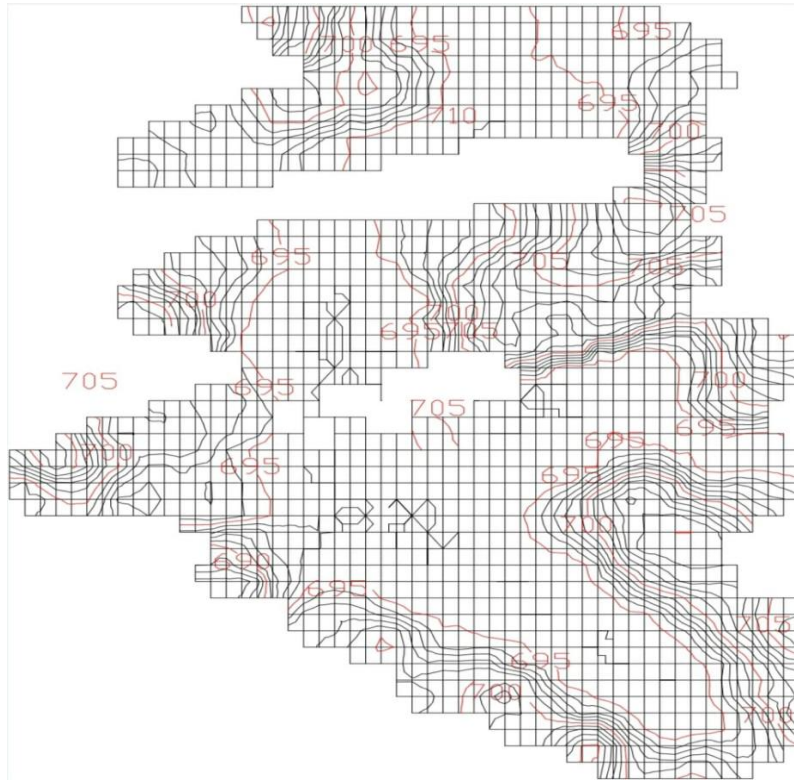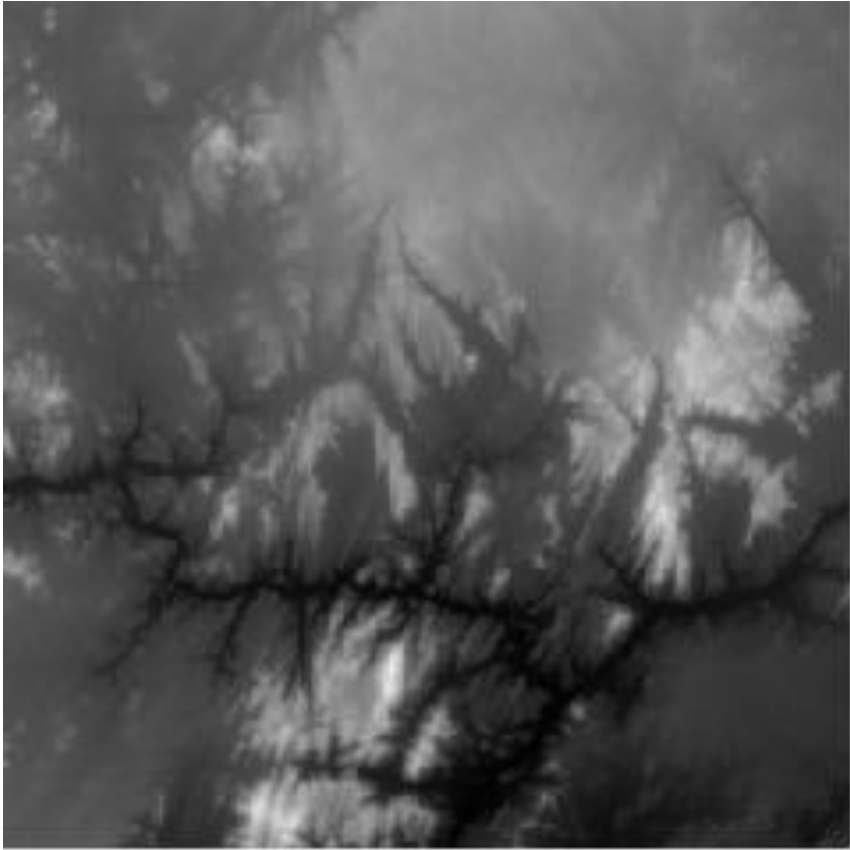

2004

2009

2013

2019

CONTOUR OBTAINED

DIGITAL ELEVATION MODEL OF THE RESERVOIR

Results