Analysis of Water Quality Parameters of Penna River from Penna Ahobilam Balancing Reservoir (PABR) to Gandikota Reservoir in Andhra Pradesh.

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Abstract. Water is one of the most precious natural resources on the planet. All living species, most ecological systems, human health, food production, and economic growth all benefit from it. Water pollution is becoming more common as a result of modern industry and population growth, since it is progressively contaminated with sewage, agricultural chemicals, oils, heavy metals, radioactive material, detergents, and other synthetic goods. The current inquiry is looking into the physical, chemical, and biological properties of the surface water of the River Penna stream, as well as the ground water of the towns nearby. In the summer, water samples from surface and ground water of 14 stream samples are collected for physical and chemical examination in March 2021. It was discovered that stream water quality had degraded to the point that it had lost its ability to purify itself. The addition of contaminants at each site resulted in an increase in the concentration of different physico-chemical parameters. In comparison to upstream locations, ground water in the mid-stream and down-stream had greater concentrations of several physico-chemical parameters. In comparison with sampling sites, Penakacharla Dam Village, had lower concentrations of electrical conductivity, total dissolved solids, total hardness i.e 120μS/cm, 1250ppm, 1150ppm. Samples at Gandikota Barrage had lower concentrations of electrical conductivity, total dissolved solids, total hardness i.e 192μS/cm, 1875ppm, 1900ppm. Surface water quality is poor for irrigation needs, with the exception of the first two upstream locations (near Jarutla Rampuram and Palyam).

Key Words: Penna river, Water quality parameters, Penna Ahobilam Balancing Reservoir, Gandikota Barrage.

1. Introduction

Water is necessary for life to exist, and its scarcity is one of the most pressing environmental concerns of the twenty-first century [1]. Rivers, which are becoming contaminated as a result of development activities such as fast industrialization and urbanisation, play a vital role in the growth of our country and the sustenance of life. They help agriculture, which relies on surface water from rivers, reservoirs, watersheds, and groundwater supplies for the majority of its water. In addition to the loss of flow into the main channel owing to dam building in the higher reaches, drainage channel deterioration, and forest cover loss, environmental pollution caused by the discharge of untreated industrial and domestic wastewater has become a serious problem. This has led in water pollution in rivers as a result of changes in the physical and chemical qualities of the water, resulting in health concerns, a loss of agricultural productivity, and soil health issues [2].

The degree of contamination is commonly determined by examining the physical and chemical properties of water bodies. Physico-chemical properties describe surface water quality, and
these parameters are subject to change as a result of various types of pollution, seasonal fluctuations, and water extraction, among other factors [3].

The self-purification process of rivers has been put under strain as a result of increased urbanisation and industrialisation. The pace at which pollutants are discharged into water bodies is considerably greater than the rate at which they are purified, which is a major source of worry. In this sense, the water quality evaluation takes into account both the current and long-term situations. In recent years, the river Ganga has received more attention in terms of cleaning and general assessment of water quality throughout its flow. The Ganga River's water quality may deteriorate further as a result of human activity [4, 8, & 9]. The goal of this study was to look at the changes in physico-chemical characteristics of the river Penna in Anantapur. Pennar and Penneru are two more names for the river Penna. It is one of South India's major east-flowing rivers. It rises in Karnataka's Nandidurg Hill Range (part of the Eastern Ghats) and flows northwest into Andhra Pradesh's Anantapur district. It runs through Karnataka's Kolar and Tumkur districts before entering Andhra Pradesh's Hindupur district. It continues eastward to the districts of Kadapa and Nellore, where it enters the Bay of Bengal. Its catchment area is between 13° 16' and 15° 52' N latitude and 77° 04' and 80° 10' E longitude.

![Figure 1. Study area showing surface sample collection points](image)

2. Materials and Methods

In the Raylaseema Region of Andhra Pradesh, water samples were collected for physico-chemical examination from 10 sampling locations near the Penna Ahobilam Balancing Reservoir (PABR), Mid
Pennar River (MPR) Dam, Pamidi Village, Chagallu Barrage, Tadipatri Town, and Gandikota Reservoir. Figure 1 shows the sampling locations. Water was collected in 1 L bottles, which were then tested for physico-chemical characteristics using conventional techniques. pH, electrical conductivity (EC), total hardness (ethylenediaminetetraacetic [EDTA] titration technique), total alkalinity (by simple titration method), chloride, and sulphate were all measured in the samples. All of the experiments were completed within 24 hours of the sample being taken. In the area of the Penna River, several ground water samples were also analysed as per Indian Standards [5, 6].

2.1. pH. The pH scale measures the concentration of hydrogen ions in water. Within 24 hours, a pH metre (Elico) is used to measure all 14 surface samples and 10 groundwater samples.

2.2. EC
EC is a measure of the total concentrations of ionized substances in water. It is expressed in μS cm−1. The samples are analyzed by using EC meter (Elico).

2.3 TDS
TDS is the measure of total amount of dissolved solids in water. It is expressed in ppm and measured using TDS Meter.

2.4 Hardness. Dissolved calcium and magnesium ions are the main causes of water hardness. Insoluble precipitates are formed when these ions interact with soap and give less lather. The presence of bicarbonates of Ca and Mg salts in the water causes temporary hardness. The presence of chlorides and sulphates of Ca and Mg ions causes permanent hardness. The hardness was determined using the EDTA technique. In the EDTA technique, the permanent complexing agent with the calcium and magnesium ions in hard water is di-sodium salt to ethylene Diamine Tetra acetic acid. At pH 9-10, the Eriochrome Black T indicator generates an unstable wine red complex. The sodium - salt of EDTA forms a stable complex after titration, with water containing Ca+2 and Mg+2 ions replacing the unstable complex. At a pH range of 9-10, Eriochrome Black T indicator gives a blue signal, indicating that the complex formation is complete.

2.5. Chloride. Water contains chloride ions in the form of NaCl, MgCl₂ and CaCl₂. The chloride ions were determined using the argentometric technique. Using potassium chromate as an indicator, the chloride ions in the water sample are measured by titrating against a standard silver nitrate solution.

2.6. Alkalinity. Alkalinity can be divided into two kinds based on titration against standard acid using either phenolphthalein or methyl orange indicator. Caustic alkalinity (carbonate) can be determined using phenolphthalein. Bicarbonate alkalinity can be found out by using methyl orange indicator. The methyl orange end point occurs only after the phenolphthalein end point. 100 ml of water sample is pipette out into a clean flask and add 2 or 3 drops of phenolphthalein indicator to the flask. The burette is filled with N/50 H₂SO₄. The end point is noted after titrating with the acid against the water sample. The endpoint is the disappearance of pink. Then continue the titration after adding 2 or 3 drops of methyl orange indicator. The endpoint is the color change from yellow to pink.

2.7. Dissolved Oxygen. The physical, chemical, and biological processes that exist in a water body influence the amounts of dissolved oxygen (D.O.) in natural and wastewaters. D.O. analysis is an important part of water pollution control and waste treatment process control. The Winkler (or iodometric) test remains the most exact and reliable titrimetric approach for D.O. analysis, having been improved by numerous techniques and equipment and supported by instrumentation. The test involves adding a divalent manganese solution to a water sample in a glass-stoppered vial, followed by a strong alkali. D.O. in the sample quickly oxidises into divalent manganous hydroxide in an equal
quantity. The oxidised manganese reverts to the divalent state in the presence of iodide ions and following acidification, with the liberation of iodine corresponding to the initial D.O. concentration in the sample. The iodine is then titrated using a thiosulphate standard solution.

2.8 Biochemical Oxygen Demand. The quantity of oxygen required for the biological breakdown of dissolved organic matter to occur under aerobic conditions and at the specified time and temperature is known as the Biochemical Oxygen Demand (B.O.D.) of water. The period is usually considered to be 5 days and the temperature to be 20°C, as per the worldwide norm. The polluting power, or strength, of sewage, industrial wastes, or contaminated water is determined using the B.O.D. test, which is one of the most significant methods in sanitary analysis. It is a measurement of the amount of clean diluting water necessary for successful sewage dilution disposal.

Fourteen surface water samples are collected as coordinates shown in Table 1 and at the points shown in the Figure 1 along the Penna River. Ten groundwater samples are collected at the coordinates shown in Table 1. These ground water samples are collected from tube wells within the vicinity of the River.

Table 1: Sampling sites and their coordinates

| Surface water samples | Coordinates | Ground water samples | Coordinates |
|-----------------------|-------------|----------------------|-------------|
| Sample No | Place | Coordinates | Sample No | Place | Coordinates |
| 1 | PABR | 14.78N, 77.3 E | 1 | Korrakodu | 14.77N, 77.26 E |
| 2 | Near Pennahobilam | 14.83N, 77.3 E | 2 | Pennahobilam | 14.83N, 77.3 E |
| 3 | MPR Dam | 14.77N, 77.38E | 3 | Penakacherla | 14.88N, 77.43 E |
| 4 | Penakacharla Dam Village | 14.88N, 77.43 E | 4 | Kalluru | 14.92N, 77.57 E |
| 5 | Kandla Palli | 14.91N, 77.44 E | 5 | Pamidi | 14.94N, 77.5 E |
| 6 | Kalluru | 14.92N, 77.57 E | 6 | Chagallu | 14.92N, 77.83 E |
| 7 | NH44 Bridge | 14.93N, 77.58 E | 7 | Tadipatri | 14.92N, 77.95 E |
| 8 | Ullikallu | 14.89N, 77.92 E | 8 | Chitrachedu | 14.93N, 77.77 E |
| 9 | Chagalu Village | 14.92N, 77.83 E | 9 | Talla Prodduturu | 14.83N, 78.06 E |
| 10 | Peddapappuru | 14.93N, 77.85 E | 10 | Near Gandikota | 14.80N, 78.22 E |
| 11 | Tadapatri | 14.92N, 77.95 E | | | |
| 12 | Bodadadi Palli | 14.87N, 78.06 E | | | |
| 13 | Talla Proddutur | 14.83N, 78.06 E | | | |
| 14 | Reservoir Gandikota | 14.80N, 78.22 E | | | |

Table 2. Summary of methods used for analysis of physico-chemical parameter of water samples [7]

| Parameter | Determination | Reference Code |
|-----------|---------------|----------------|
| Colour    | Cobalt scale  | IS3025(part4)  |
3. Results and Discussion

The surface water samples of Penna River are collected from 14 locations in the month of March 2021 and are shown in Table 1 and Table 2. Ground water samples are collected from the household bores or field bores near to the surface sampling points itself. Ten groundwater samples are also collected and tested. The values of surface and groundwater samples are mentioned in Tables 3, 4, 5, 6 and 7.

Table 3. Physico-chemical properties of Penna River water samples. (pH, Temperature, Colour, Ec, Acidity)

| Sampling Site          | Sample Number | pH   | Temperature (°C) | Colour       | EC (µS/cm) | Acidity (ppm) |
|------------------------|---------------|------|------------------|--------------|------------|---------------|
| PABR                   | 1             | 7.6  | 37               | Green        | 120        | 1075          |
| Near Pennahobilam      | 2             | 7.9  | 37               | Light green  | 123        | 1675          |
| MPR Dam                | 3             | 7.87 | 30               | Pale green   | 122        | 850           |
| Penakacharla Dam Village| 4          | 7.77 | 35               | Green        | 120        | 850           |
| Kandla Palli           | 5             | 7.85 | 37               | Pale Green   | 141        | 800           |
| Kalluru                | 6             | 7.79 | 36               | Colorless    | 134        | 800           |
| Nh44 Bridge            | 7             | 7.9  | 39               | Colorless    | 129        | 775           |
| Ullikallu              | 8             | 7.86 | 35               | Colorless    | 120        | 825           |
| Chagalu Village        | 9             | 7.9  | 33               | Colorless    | 135        | 850           |
| Peddapappuru           | 10            | 8.1  | 34               | Colorless    | 142        | 875           |
| Tadapatri              | 11            | 8.01 | 39.2             | Colorless    | 156        | 1025          |
| Bodadadi Palli         | 12            | 8.2  | 39               | Light Black  | 190        | 1600          |
| Talla Produttur Reservoir | 13         | 8.12 | 38               | Pale green   | 185        | 1625          |
| Gandikota              | 14            | 8.15 | 37               | Green        | 182        | 1575          |
Table 4. Physico-chemical properties of Penna River water samples. (Alkalinity, Total Hardness, Temporary Hardness, BOD, DO)

| Sampling Site                          | Sample Number | Alkalinity (ppm) | Total Hardness (ppm) | Temporary Hardness (ppm) | BOD (ppm) | DO (ppm) |
|----------------------------------------|---------------|------------------|----------------------|--------------------------|-----------|----------|
| PABR                                   | 1             | 300              | 1250                 | 1150                     | 12        | 5.3      |
| Near Pennahobilam                      | 2             | 350              | 1225                 | 1175                     | 12        | 5.3      |
| MPR Dam                                | 3             | 325              | 1250                 | 1150                     | 14        | 5.6      |
| Penakacharla Dam Village               | 4             | 550              | 1250                 | 1100                     | 13        | 5.5      |
| Kandla Palli                           | 5             | 350              | 1300                 | 1125                     | 11        | 5.2      |
| Kalluru                                | 6             | 300              | 1350                 | 1200                     | 10        | 5.7      |
| Nh44 Bridge                            | 7             | 600              | 1425                 | 1225                     | 14        | 5.6      |
| Ullikallu                              | 8             | 350              | 1500                 | 1350                     | 15        | 5.5      |
| Chagalu Village                        | 9             | 675              | 1525                 | 1300                     | 12        | 5.9      |
| Peddapappuru                           | 10            | 700              | 1625                 | 1425                     | 14        | 5.4      |
| Tadapatri                              | 11            | 750              | 1675                 | 1500                     | 16        | 5.9      |
| Bodadadi Palli                         | 12            | 1075             | 1875                 | 1775                     | 19        | 5.7      |
| Talla Produttur                        | 13            | 1150             | 1880                 | 1675                     | 18        | 5.6      |
| Reservoir Gandikota                    | 14            | 1220             | 1975                 | 1800                     | 18        | 5.8      |

Table 5. Physico-chemical properties of Penna River water samples. (Total dissolved solids, Total settled solids, Total volatile solids Total fixed solids, Total solids)

| Sampling Site                          | Sample Number | TDS (ppm) | TSS (ppm) | TVS (ppm) | TFS (ppm) | TS (ppm) |
|----------------------------------------|---------------|-----------|-----------|-----------|-----------|----------|
| PABR                                   | 1             | 221       | 1004      | 1000      | 225       | 1225     |
| Near Pennahobilam                      | 2             | 224       | 1051      | 1044      | 220       | 1275     |
| MPR Dam                                | 3             | 220       | 1003      | 991       | 232       | 1223     |
| Penakacharla Dam Village               | 4             | 225       | 1002      | 971       | 256       | 1227     |
| Kandla Palli                           | 5             | 250       | 1014      | 987       | 272       | 1256     |
| Kalluru                                | 6             | 238       | 1014      | 932       | 320       | 1252     |
| Nh44 Bridge                            | 7             | 227       | 1025      | 899       | 353       | 1252     |
| Ullikallu                              | 8             | 220       | 1066      | 924       | 362       | 1286     |
| Chagalu Village                        | 9             | 240       | 1049      | 905       | 384       | 1289     |
| Peddapappuru                           | 10            | 255       | 1044      | 907       | 392       | 1299     |
| Tadapatri                              | 11            | 270       | 1064      | 937       | 397       | 1334     |
| Bodadadi Palli                         | 12            | 300       | 1072      | 971       | 401       | 1372     |
| Talla Produttur                        | 13            | 297       | 1088      | 965       | 420       | 1385     |
| Reservoir Gandikota                    | 14            | 299       | 1222      | 1076      | 445       | 1521     |
Figure 2. Variation in total solids, dissolved solids, suspended solids.

Figure 3. Variation of total solids, fixed solids, volatile solids.

Figure 4. Variation of acidity.

Figure 5. Variation of alkalinity.

Figure 6. Variation of hardness.

Figure 7. Variation of temperature.
The value of pH for surface water is within the range of portable water (6.5 to 8.5) and values are in between 7.6 at PAB Reservoir and 8.12 at Gandikota Reservoir as shown in Table-3. This is due to the presence of dolomite geological formations in that region. pH values of groundwater varies from 8.21 near korakodu to 8.5 near Gandikota as shown in Table-5. The value of temperature is also within the normal range i.e 30 to 38 deg C as shown in Table-3. The surface water temperature values are also depends upon atmospheric values. The variation of temperature of surface water is shown in Figure 7. Temperature values for groundwater vary from 20 to 25 deg C as shown in Table-6.

The colour of surface water samples are green and black for some surface samples indicating contamination of sewage water or algae. For groundwater, the samples are colourless. The colour of flowing water is generally colourless. When water is stored in reservoirs it gets blue – green colour due to algae. The water from reservoirs shows the presence of algae. Acidity values are high in initial and final sampling points. And in between the flow, the values got decreased.

Electrical Conductivity (EC) varies for surface samples from 120 μS/cm at PABR to 192 μS/cm at Gandikota Barriage as shown in Table-3. Electrical Conductivity values are within the limits of irrigation water (less than 200 μS/cm). The EC values follow an increasing trend from PABR to Gandikota Barrage. For groundwater samples, EC values varies are in between 300 and 400 μS/cm as shown in Table-6. This indicates the presence of some dissolved salts in the groundwater.

Acidity values for surface samples are in between 750 and 1600 ppm as shown in Table-3. The variation of acidity from PABR to Gandikota Barriage is shown in Figure 4. The acidity values for ground water samples are within the range of 300 and 400 ppm as shown in Table-6. The increase in acidity values indicates the contamination due to industries or geological formations. Alkalinity values for surface samples are in between 300 and 1220 ppm as shown in Table-4. The variation of acidity from PABR to Gandikota Barriage is shown in Figure 5. Alkalinity values are higher than normal values near Tadipatri due to the presence of stone quarries and limestone formations. The alkalinity values for ground water samples are within the range of 500 and 1000 ppm as shown in Table-7. The permissible value for alkalinity is 300ppm for drinking water and suitable treatment is necessary.

Total hardness of surface samples varies from 1250ppm at PABR to 1975ppm at Gandikota Barriage as shown in Table-6. The variation is shown in Figure 5. This increasing trend in hardness in surface water samples is due to the presence of dolomite formations near Tadipatri region and also due to the excessive limestone and granite quarrying near Tadipatri region of Anantapur dt. For ground water samples total hardness values varies from 1300ppm to 1975ppm as shown in Table-7. Total hardness is permissible up to 500ppm. But the obtained values are greater than 500ppm. So it requires softening before consumption.

Temporary hardness values for surface samples are within range of 1000 and 2000 ppm. This is shown in Table-4. This variation of Temporary hardness is shown in Figure 6. For groundwater samples temporary hardness values are in between the 500 and 810ppm as shown in Table 7. This temporary hardness can be removed easily by addition of lime or boiling or with minor softening. For surface samples, BOD values are in between 12 and 18 ppm as shown in Table-4. BOD values are in between 4.5 and 6ppm for groundwater samples from 1 to 10 as shown in Table-7. This indicates the requirement of preliminary treatment before the consumption.
For surface samples, BOD values are in between 12 and 18 ppm as shown in Table 4. BOD values are in between 4.5 and 6 ppm for groundwater samples from 1 to 10 as shown in Table 7. This indicates the requirement of preliminary treatment before the consumption. For surface samples, DO values are in between 5.3 to 8 ppm as shown in Table 4. These DO values are suitable for the growth of aquatic life. DO values are in between 4.5 and 6.5 ppm for groundwater samples from 1 to 10 as shown in Table 7.

For surface samples, the values of total solids, suspended solids, dissolved solids, volatile and fix solids is shown in Table 5 and for groundwater samples it is shown in Table 7. Variation of total solids, suspended and dissolved solids for surface samples is shown in Figure 2 and variation of total solids, organic and volatile solids for surface samples is shown in Figure 2. The values of total dissolved solids and total suspended solids indicate the requirement of sedimentation and coagulation. The permissible range of total solids is 500 ppm for portable water.

Table 6. Analysis of water quality parameters of Ground water (pH, Temperature, Ec, TDS, Acidity)

| Place       | Sample Number | pH     | Temperature (°C) | EC (μs/cm) | TDS(ppm) | Acidity (ppm) |
|-------------|---------------|--------|------------------|------------|----------|---------------|
| Korrakodu   | 1             | 8.21   | 21               | 351.9      | 221      | 321           |
| Pennahobilam| 2             | 8.32   | 23               | 331        | 228      | 332           |
| Penakacherla| 3             | 8.33   | 22.5             | 327.1      | 236      | 339           |
| Kalluru     | 4             | 8.24   | 22.8             | 346        | 341      | 348           |
| Pamidi      | 5             | 8.27   | 23.5             | 347.1      | 332      | 369           |
| Chagallu    | 6             | 8.34   | 23.7             | 351.9      | 349      | 378           |
| Tadipatri   | 7             | 8.35   | 23.9             | 355.2      | 356      | 382           |
| Chitrachedu | 8             | 8.4    | 24               | 361.7      | 367      | 391           |
| Prodduturu  | 9             | 8.42   | 24.6             | 382.3      | 385      | 397           |
| Near Gandikota | 10       | 8.46   | 24.9             | 389.7      | 393      | 402           |

Table 7. Analysis of water quality parameters of Ground water (Alkalinity, Total Hardness, BOD, DO)

| Place       | Sample Number | Alkalinity (ppm) | Total Hardness (ppm) | Temporary Hardness (ppm) | BOD (ppm) | Dissolved oxygen (ppm) |
|-------------|---------------|------------------|----------------------|--------------------------|-----------|------------------------|
|              |               |                  |                      |                          |           |                        |
4. Conclusions

- Fourteen samples of surface water and 10 samples are groundwater are analysed for the various physical and chemical parameters from Penna Ahobilam Balancing Reservoir (PABR) to Gandikota Barrage and results are discussed in this paper.
- The presence of algae is indicated in the Penna Ahobilam Balancing Reservoir, Mid Pennar River Dam, Chagallu Barriage and Gandikota Reservoir based on the color. It affects drinking water as well as irrigation water quality. Necessary steps are to be taken to control the growth of algae.
- Hardness of water is more in Tadipatri region and Gandikota Reservoir due to excessive quarrying operations and dolomite formations.
- The leachate from stone quarries reaches to Penna river and may increase the hardness. Necessary steps have to be taken to prevent the leachate from reaching Penna River.
- Water requires primary treatment like sedimentation aided with coagulation is required to remove some hardness, alkalinity, acidity to maintain the nearer values for portable water.
- Ground water is also hard in nature and requires softening operations.

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