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# Assessment of Groundwater Quality for Drinking and Domestic Purposes of Nellikal Watershed, Nalgonda District, Telangana, India

**Hari Ramavath[1] and Panduranga Reddy Inavole[1]**
[1]Department of Geology, Osmania University, Hyderabad 500007, Telangana, India.

**Corresponding author:**
**Mr. Hari Ramavath**
Research Scholar
Department of Geology, University College of Science, Osmania University
Hyderabad 500007, Telangana, India.
E-mail: ramavath.hari@gmail.com
Cell: 9705624227.

**Abstract**

Groundwater is an important natural resource, the core of the ecosystem, and a necessary factor for human survival. The objective of the study to evaluate the groundwater quality through hydrogeochemical investigations in a fluoride endemic region. A total of 34 groundwater samples are collected from Nellikal watershed and analyzed for physicochemical parameters and major ions using APHA standard methods. The abundance of major ions following the order, anions: $HCO_3^-$>$Cl^-$>$NO_3^-$> $SO_4^{2-}$> $F^-$ and cations: $Na^+$> $Ca^+2$> $Mg^{+2}$> $K^+$ respectively. Results reveal that nitrate concentrations are beyond the WHO permissible limits in 44% of the samples. Agriculture fertilizer wastes leaching might be one of the significant sources of nitrate contamination in groundwater as the study region is dominant with agricultural activities. However, 11% of samples found fluoride concentration above highest desirable limit BIS standards for drinking purposes. These findings suggest that the proper treatment is required before supply to the public to protect their health.

**Keywords:** Groundwater quality, Hydrogeochemistry, WHO permissible limits, Nellikal Watershed, Telangana.

## 1.Introduction

The Nellikal watershed is situated in the Nalgonda district, Telangana, at a distance of 130km northeast of Hyderabad, capital of the state of Telangana. The watershed, covering an area of about 120km$^2$ is positioned between latitude 16$^0$34’30”N and 16$^0$40’30”N to longitude 79$^0$18’00”E and 79$^0$27’00”E falling in the Survey of India (SOI) topo sheet number 56 P/2 (Fig.1.1).

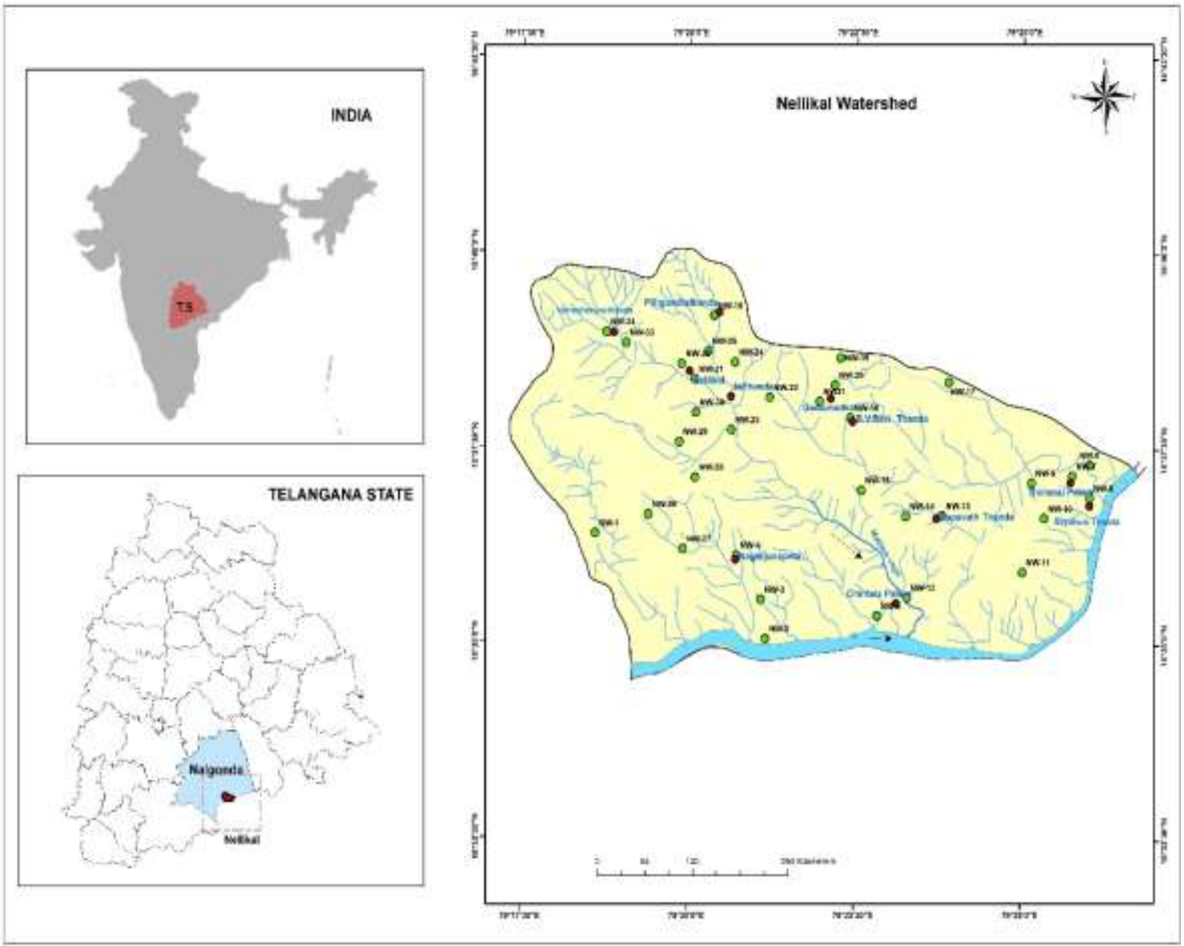


**Figure 1.1** Geographical location map of Nellikal watershed

Nellikal watershed has an artificial water reservoir i.e. Nagarjuna Sagar Dam. This is masonry dam constructed across the Krishna River at Nagarjuna Sagar that overlaps the broader of Nalgonda district (Telangana) and Guntur district (Andhra Pradesh). The index area Nellikal village a view point to Nagarjuna Sagar and became a tourist location. Also noticed there is no industrial intervention in the study region. However, agriculture is the common practice through which people living in this area as their mere source of income. Nellikal watershed is home to a population of 22,456 inhabitants with an average population density of 189 persons per $km^2$ consists of 18 villages. It was observed that groundwater levels range between depths of 16 to 30 m bgl. The area is categorized as overexploited due to the large groundwater abstraction for the irrigation of crops, mainly paddy and cotton.

## 2. Geology and structural features

There are three type of geology formations are observed in study area. They are the Quartzite with shale (QS); Granite, granodiorite and granite gneiss with xenoliths of tonalite, Trondhjemite, Pyroxene granite, granodiorite & biotite schist (Ggn); and Quartzite with conglomerate (QC) comprise granites, gneisses, schists and intrusive. Geology map of the study area is presented in Figure 2.1. The consolidated metasedimentary rocks of Cuddapah and Kurnool system comprising conglomerate, quartzites and shales occupy 70% in the southern part of the study region. The unconsolidated deposits comprising alluvial sands, clay, occur as isolated and narrow patches along the major rivers and streams occupying around 2% of the area. A linear NW-SE trending. The litho units in the 2 km wide belt are quartzite-shales and Banded Iron Formation (BIF). Banded and intensely deformed tonalite gneiss may be older basement gneiss occurs as discrete outcrops of small dimensions within granodiorite terrain close to the schist belt.

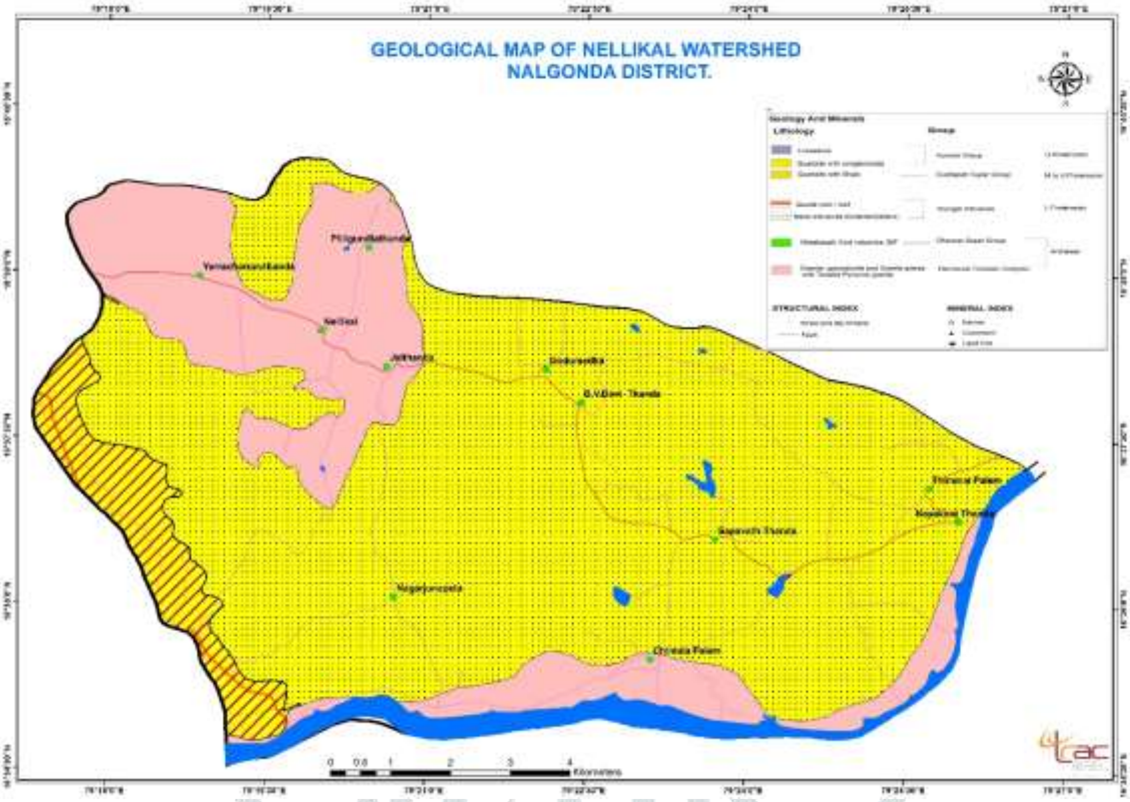


**Figure 2.1** Geology map of the Nellikal watershed

The geological formations in the area include unclassified granites and gneisses of Archean age, Cumbum shales, Phylllites, Srisailam quartzites of the Cuddapah super group and shales of the younger Kurnool group of the rocks. The hornblende schists and amphibolites (Older Metamorphics) which are oldest rocks occur, as rafts, enclaves and discontinuous linear bands, within the Peninsular Gneissic Complex. The distinct comprises migmatities, granites granodiorite, tonalitic-trondhjemite suite of rocks and hornblende-biotite schist, metabasalts, meta-rhyolite and banded hematite quartzite and Dharwar super group are exposed as linear belts near Nellikal on the Hyderabad-Nagarjuna Sagar road.

## 3. Material and Methods

There is a dominancy of dendritic drainage system, stream order system from lowest first order to highest fourth order as shown in Figure 3.1. The study region is drained by the Krishna River along with tributary of Peddavagu rivers and small streams like Mattam vagu. Krishna River forms the southern boundary and enters the south to eastern part of the study area. All other lower order streams and nallas are controlled by minor lineaments. The major river Krishna is perennial and all other rivers are seasonal and ephemeral. Generally, drainage pattern observed is dendritic to sub-dendritic and rectangular (CGWB, 2013).

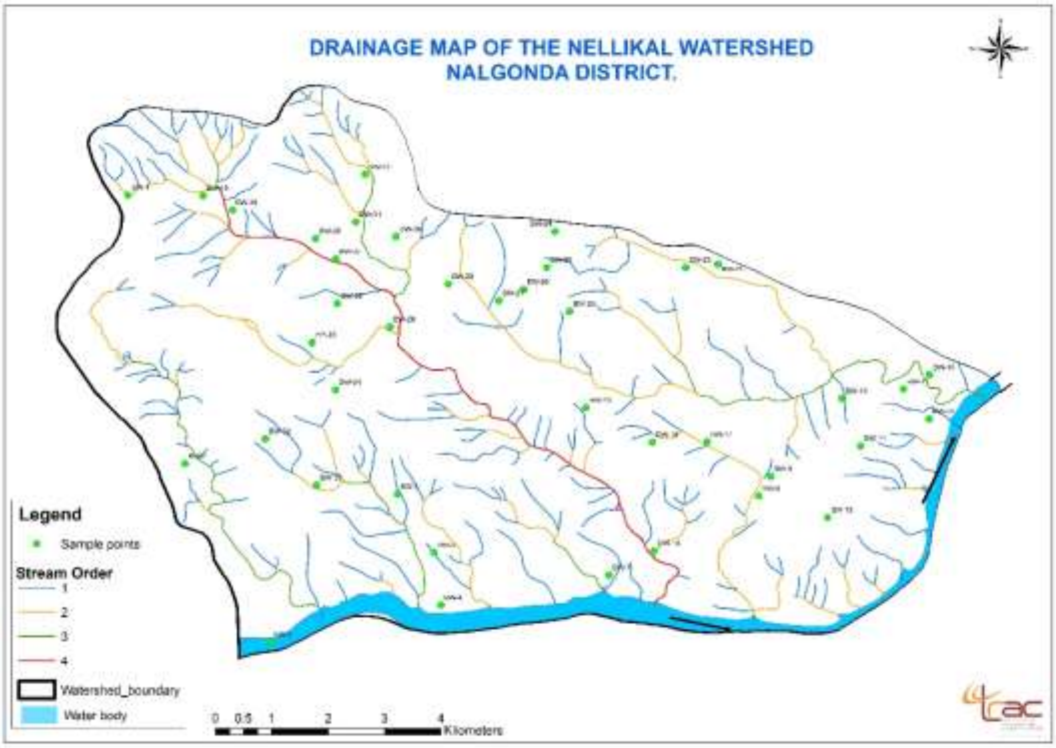


**Figure 3.1** Drainage pattern and stream order map of the Nellikal watershed

## 4. Hydrogeochemistry

Hydrogeochemical studies are necessary to distinguish the discrepancies in ionic concentrations for utilization in various sectors such as drinking, domestic, irrigational etc. to evaluate its composition in the respective study regions (Marghadstu et al. 2011; Ledesma-ruiz et al.2016). Groundwater condition reflects through a combination of physical, chemical and biological characteristics, which are influenced through both natural sources and anthropogenic activities. Physical properties majorly depend on groundwater flow pattern, volume, speed, and its direction. The chemical and biological parameters influenced by either natural and man-made activities. (https://www.epa.gov/report-environment/water). Groundwater pollution not only influence its quality but also render disorder to a health problem, economic growth, and social life (Singh and Kamal 2017; Marcovecchio et al. 2007). Understanding the groundwater quality is a major concern as future survival of life on the earth will depend on our present management and utilization of this precious natural resources. Groundwater geochemistry in pheratic aquifers of the hard rock volcanic provinces is potentially vulnerable due to anthropogenic inputs such as unrestricted industrialization, landfill site and agricultural run-off (Kumar et al. 2008; Mukate et al. 2020; Kale et al.2010). The properties and quality of water is controlled by the sum budget of physico-chemical parameters and major ions present in the groundwater. For instance, lower value of pH in drinking water can result to gastrointestinal problem, so, it is not recommended to drink. Total Dissolved Solid (TDS) evaluate the water portability and for irrigation uses (Davis and DeWiest, 1966). Groundwater hydrochemistry is an essential characteristic that determines the water quality as it explains the inter-relation between ions constituents and their sources of pollutants either through geogenic/anthropogenic (Woo et al., 2000). Further, major ion chemistry helps in deciphering the sources and characterizing the hydro-geochemical processes occurring in the aquifer (Voutsis et al., 2015). The extent of contamination of groundwater resource is a liable on physicochemical parameters, presence of major ions including some of toxic/trace metals (Tiwari et al. 2017).

The groundwater samples were determined for physicochemical parameters, anions and cations. Details of equipment and methods adopted (APHA 2017) for measured for groundwater samples in this study were presented in Table 4.1

**Table 4.1.** Analytical methods used for determining the hydrogeochemistry of groundwater samples.

| Category | Parameters | Method/instrument | Reagent | Units | Reference |
|---|---|---|---|---|---|
| General | pH | pH/EC/TDS meter | pH buffers 4,7 and 9.2 | ------ | APHA 2005 |
| | EC | pH/EC/TDS meter | Potassium chloride | µS/cm | APHA 2005 |
| | TDS | EC*0.64 | EC*0.64 | mg/l | APHA 2005 |
| | Total Hardness | EDTA titrimetric | EDTA, ammonia buffer, Eriochrome Black-T (EBT) | mg/l | APHA 2005 |
| | Total Alkalinity | Acid-base titration | Sulfuric acid, Phenolphthalein indicator, Methyl orange | mg/l | APHA 2005 |
| Cations | Na+ | Ion chromatography (IC) Metrohm | 1.7 mmol/L nitric acid and 0.7 mmol/L dipicolinic acid | mg/l | ASTM D6919-09 |
| | K+ | Ion chromatography (IC) Metrohm | 1.7 mmol/L nitric acid and 0.7 mmol/L dipicolinic acid | mg/l | ASTM D6919-09 |
| | Ca2+ | Ion chromatography (IC) Metrohm | 1.7 mmol/L nitric acid and 0.7 mmol/L dipicolinic acid | mg/l | ASTM D6919-09 |
| | $Mg^{2+}$ | Ion chromatography (IC) Metrohm | 1.7 mmol/L nitric acid and 0.7 mmol/L dipicolinic acid | mg/l | ASTM D6919-09 |
| Anions | F- | Ion chromatography (IC) Metrohm | 3.2mM $Na_2CO_3$ and 1.0mM $NaHCO_3$ | mg/l | ASTM D4327-11 |
| | Cl- | Ion chromatography (IC) Metrohm | 3.2mM $Na_2CO_3$ and 1.0mM $NaHCO_3$ | mg/l | ASTM D4327-11 |
| | NO3- | Ion chromatography (IC) Metrohm | 3.2mM $Na_2CO_3$ and 1.0mM $NaHCO_3$ | mg/l | ASTM D4327-11 |
| | $SO_4$2- | Ion chromatography (IC) Metrohm | 3.2mM $Na_2CO_3$ and 1.0mM $NaHCO_3$ | mg/l | ASTM D4327-11 |

| | | | | | |
|---|---|---|---|---|---|
| | HCO3- | Acid-base titration | sulfuric acid, Phenolthalein indicator, methyl orange | mg/l | APHA 2005 |

## 5. Health risk assessment

Health risk assessment is an essential method for evaluating the possible health effects in water environment caused by numerous contaminants (USEPA 2014; Aradhi and Kurakalva 2014; Kurakalva et al., 2021). This method has been extensively utilized by many researchers in literature for the estimation of the adverse health effects possible from exposure to contaminated water (Sun et al., 2007; Kavcar et al., 2009). According to Mukherjee and Singh (2018), around 660 lakhs people in India are facing health problems due to drinking of groundwater with highly harmful dissolved elements with above permissible limits such as arsenic, fluoride, nitrate and boron from 19 states which includes 60 lakhs children under 14 years. About 80% of human diseases are due to the consumption of contaminated water (Felsenfeld and Roberts, 1991). One of the best examples is 'cholera' outbreak due to consumption of contaminated water during 1970-1971 affecting about 4 lakhs people. Further, Egbueri (2020) and WHO (2011) explained diseases such as typhoid, teeth fluorosis, skin infection, infantile paralysis, cholera, dysentery, diarrhoea, lead poisoning, guinea worm disease etc from drinking contaminant water.

One most common health issue in India is due to consumption of fluoride and nitrate contaminated groundwater. It's reported that in India, over 10.82 crores population drink water containing with high nitrate beyond permissible level, i.e., 100 mg/L (Balamurugan et al., 2020). From Teng et al. (2019), nitrate risk in groundwater is due to high uses of agro-fertilizers for more crop yielding which later led to degradation of groundwater quality through leaching. So, the major man-made impact on nitrate contamination in groundwater is fertilizers using in agricultural sector, water treatment plants, sewage and industrial runoff. natural processes for nitrate contamination in groundwater is due to nitrogen fixation through legume plants and microbes and leaching through soil and rock layers (Adimalla, 2019). Drinking permissible limits for nitrate is 45 mg/L according to WHO (2011).

## 6.Results and Discussion

Data were collected from the India-WRIS website from the concerned monitoring station from the year 2016 to 2021. The groundwater quality of the Nellikal Watershed,Nalgonda District, Telangana, has been analyzed for two year 2019 to 2021.

The above result indicates poor quality water is occurring in the study area. Study of recharge of the aquifer by the managed aquifer recharging (MAR) method was proposed. Evaluation of the GWQI including aquifer recharge and tentative improved outcomes were obtained.

This was accomplished by identifying connections or relationships among groundwater factors of the zone. The connection grid assesses the relationship coefficients between groundwater hydro-geochemical factors. Positive and negative connections are considered for seeing how strong or weak linear relationships existed between groundwater parameters. Hydro-geochemical factors have been introduced in Pearson's connection grid. The presence of an extreme connection (0.92) among electrical conductivity and Cl is credited to augmentation of dissolved constituents that points to increments in the electrical conductivity of the particles. Ca, F, Mg, $NO_3$, and $SO_4$ have solid positive connection coefficients with total dissolved and electrical conductivity showing their contribution to the development of dissolved particles in groundwater, along these lines, expanding the electrical conductivity of the ionized water. Poor correlations are additionally found among factors of significant particles (e.g. F and $NO_3$). Negative and poor correlation coefficients are seen among $NO_3$ and significant particles in the study area.

## 7. Conclusion

1. The water quality index is helpful in the assessment and management of water quality. The present investigation represents the groundwater quality assessment for the Nellikal watershed, Nalgonda District, Telangana.
2. It highlights the salient features of various important chemical parameters acting upon the general water quality. The baseline data generated in these investigations and their analysis and interpretation will go a long way in improving our understanding and knowledge base about the status of water quality of a socio-economically vital fluvial system.
3. The study has both academic value and practical significance. Based on the observed WQI results it can be concluded that the respectably high concentrations of EC, TDS, Cl, $SO_4$, $NO_3$, and F and so on in groundwater were found close to landfill, which disintegrates its quality for drinking and other homegrown purposes.
4. The result of this study indicates that ground water quality occurs in the poor' range as per BIS standards.

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