1. INTRODUCTION

Water is principle need of all life forms on earth. Water occupies three fourth of the earth surface. Water is finding in many different forms and in many different places. The total amount in hydrological cycle is constant. Its distribution and conditions varied from place to place. Excess water leads to flood and lack results drought. Therefore, it becomes a precious national asset. Water on the surface of the planet called surface water.

As per 2011 census, the per capita availability of drinking water in India is 1545 cubic meters (pib.nic.in/news/erelease). At 2050, the demand for water in India will rise dramatically to about 899 cubic kilometers (www.wwf.org). As per 2001 census the estimated demand in Tamil Nadu was 54,395 million cubic meters (1921 TMC) which will likely to go up to 57,725 million cubic meters in 2050 (www.environment.tn.nic.in/SoE/images/Waterresources). Tamil Nadu face water deficit due to increasing population, urbanization and industrialization. Geographically, many districts of Tamil Nadu positioned in rain shadow region of Western Ghats and experience less rainfall. Kanyakumari district located at the foot hill of Western Ghats and receive rainfall both southwest and northeast monsoon.

Kodayar River is the principle river of Kanyakumari, which rises from the Agastiar malai of Western Ghats (www.cgwb.gov.in/District_Profile/TamilNadu/Kanyakumari). On the way near the village Pechiparai, a reservoir was build across the Kodayar. It is about 43 km away from Nagercoil, the headquarters of Kanyakumari district. The reservoir total catchment area is about 207.19 km2. Its depth is about 14.63 meters. The water drop lets from Western Ghats exclusively accumulate in this dam. Pechiparai reservoir water flow through system of canals
throughout Kanyakumari district and part of Tirunelvelli district spread over an area of 100.7 sq km (timesofindia.indiatimes.com/city/madurai). Water is stored in many ponds in order to ensure continuous supply for agricultural needs. The surplus water flows in to Arabian Sea at Thengapattanam.

The ponds and reservoirs are the temporary storage area of surface water. They are home for many wild lives. They help to maintain the water table, nutrient recycling and to do many multipurpose beneficial activities like irrigation, fisheries, recreation and drinking. The biotic and abiotic factors in the water body determine the character of water body. Biotic constituents of all natural water play a vital role in biogeochemical cycle. Some biotic and abiotic elements in the aquatic ecosystem act as indicator of water pollution.

The surface waters are easily susceptible to contamination with microorganisms from different sources (Pelczar et al., 1993). The constituents of water determine the goodness of water for particular purpose. The status of water is total sum of all physical, chemical and biological characters of water that influence its beneficial use. Water quality assessment generally involves analysis of physico-chemical and biological parameters (Kulshrestha and Sharma, 2006; Rajagopal et al., 2010). Testing of water attribute explain the health of water bodies. Because of the significance of water, several government and non-government organizations prescribe limitations for physico chemical and biological criterion.

The water colour is due to the absorption of visible light by dissolved substances, colloidal substances and suspended particles, type of vegetation, plankton community, minerals and decaying matter. The presence of aquatic humic acid makes the water yellow green colour (Sodhi, 2002). The variation in water taste
is depends on presence and absence of microorganisms, concentration of carbon
dioxide, presence and absence of salts, minerals and metals such as calcium, sodium,
iron and chlorine. The naturally occurring dissolved calcium in the water, produce
bitter taste. The presence of inorganic gases like ammonia, chlorine, hydrogen,
sulphide and organic chemicals like biological decaying by products, pesticides,
insecticides give special odour to the water. The presence of actinomycetes in water
produce earthy or musty odour and organo-phosphorous compounds imparts fishy
odour (Sodhi, 2002).

The pond water temperature mainly depends on climatic zone, season, altitude, inflow of agricultural and urban sewage runoff. Therefore, it varies
throughout the year with seasonal changes in air temperature, day length, and solar
radiation. The rate of all biochemical activities in aquatic bodies are temperature
dependent. It determines pH, conductivity and various form of alkalinity (Trivedy
and Goel, 1986).

The pH is a scale used to examine the concentration of hydrogen ion in
water. Many reactions that control water constitutions are pH dependent. It is a
crucial factor for all living organisms, biochemical processes and industrial water
use. Carbon dioxide concentration directly influences the pH. Because of
carbonates most of the natural water is alkaline. Diurnal fluctuations, exposure to air
and natural biochemical activities in water, alter the water pH Acidic waters are
highly corrosive and it will produce sour taste (Trivedy and Goel, 1986).

The salinity is a measure of dissolved salts like magnesium, calcium,
carbonate, bicarbonate, nitrate and sulfate in water. The suitability of water for
drinking, irrigation, or wildlife depends on the type and concentration of dissolved
salts in water. Scrutinize the electrical conductivity is a good way to determine the ionic strength of water. The ability of water to conduct electrical current is proportional to the number of ions in the water. It is a rapid measure to find out the total dissolved solids in water (Trivedy and Goel, 1986; Abdar, 2013). Chemically pure water should not conduct electric currents. Hike in electrical conductivity directly indicates presence of electrolytes in the form of pollution (Angell, 1982). The rate of decomposition of organic matter fluctuate the values of conductivity (Meenakshi Saxena, 2012). Saline water freely conducts electricity more than pure water. Fresh water is a weakened solution of calcium bicarbonate. Salt water is a more concentrated solution of sodium chloride.

The CO$_2$ is high soluble in water either free or combined with calcium or magnesium to form carbonates and bicarbonates. Biological oxidation of organic matter produce excess of free CO$_2$ but oxygenates in water remove free CO$_2$. Aquatic plant life depends upon carbon dioxide and bicarbonates in water for growth. During photosynthesis, phytoplankton utilizes carbon dioxide as the carbon source and converts it into organic compounds.

The hardness of water refers to soap neutralizing capacity of water. It depends on metal ions dissolved in surface water. Its primary cause is calcium and magnesium ions (Murugesan and Rajakumari, 2005). Hardness caused by calcium is calcium hardness and by magnesium is magnesium hardness. Carbonate and bicarbonate salts of calcium and magnesium produce carbonate hardness. Other than carbonate and bicarbonate, salts such as chloride, sulphate of calcium and magnesium produce non-carbonate hardness. The total hardness expressed as the sum of the carbonate hardness and non-carbonate hardness.
The alkalinity is a scale, used to study the water's ability to neutralize an acid (Trivedy and Goel, 1986). Alkalinity is associated with dissolved CO\(_2\) i.e. amount of carbonate (CO\(_3^{2-}\)) and bicarbonate (HCO\(_3^-\)) in water. If alkalinity is less than or equal to total hardness, it is temporary. Bicarbonate hardness is temporary hardness and it can be eliminated by boiling (Murugesan and Rajakumari, 2005), to expel the CO\(_2\). Permanent hardness is due to the presence of the ions Ca\(^{2+}\), Mg\(^{2+}\), Fe\(^{3+}\) and SO\(_4^{2-}\) and it cannot be eliminate by boiling.

The total dissolved solid (TDS) is an important parameter in drinking water, used to read up the amount of dissolved carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions in water. Chlorides are one of the major inorganic anions present in natural water. Chloride results from agricultural activities, domestic sewage and chloride rich rocks. Human body releases very high quantity of chloride in the form of urine (Murugesan and Rajakumari, 2005). High concentration of chloride considered as indicator of pollution by high organic wastes of animal or industrial origin.

DO and BOD data used to read the pollution status of aquatic system. The DO is a direct measure to investigate the amount of oxygen freely available in water. It decides the excellence of water. It also decides the type of physical, chemical and biological process going on inside the water body (Murugesan and Rajakumari, 2005). Oxygen demanding wastes in water, readily utilized the free O\(_2\). Do in water is due to direct diffusion from air and photosynthetic activity of autotrophs (Dara, 2009).

The BOD is an empirical test used to analyze the amount of oxygen required by the living organisms engaged in the utilization and ultimate destruction or
stabilization of organic waste in the water (Murugesan and Rajakumari, 2005). BOD is direct measures justify the amount of organic waste and sewage strength in the water body (Trivedy and Goel, 1986; Dara, 2009).

The sodium is naturally occurring cation in water. It is highly soluble in water. At low concentration, there is no adverse health effect. However, at high concentration it will produce cardiovascular diseases (Trivedy and Goel, 1986). Sodium is associated with chloride and sulphates, which make the water salty. High concentration of sodium in irrigation water affects the soil permeability and texture. Nitrates are essential plant nutrient, excess cause eutrophication. Excess nitrates can cause hypoxia (low levels of DO) and are toxic to warm blooded animals at high concentrations (10 mg/l) under certain conditions (EPA). Elevated nitrate in drinking water can also cause human health problems (www.atsdr.cdc.gov/HAC/pha/reports). Nitrogen fixing microorganism such as bacteria and blue green algae fix atmospheric nitrogen (Trivedy and Goel, 1986).

Phosphate is an important plant nutrient. Phosphates in water interpret pollution status of water. Phosphate content is very low in natural water and limits the growth of phytoplankton and macrophytes. Both organic and inorganic phosphate dissolved or suspended in the water. Aquatic plants used dissolved inorganic phosphate and it becomes part of their tissue (EPA). Bacterial decomposers decompose suspended organic phosphates. Excess amount of phosphates leads to eutrophication.

Dirty water accommodate only bacteria (Pelczar et al., 1993), because of the lack of oxygen, purification process alone carried out and release CO₂. Rich diversity of algae sheltered in organically contaminated water (Pelczar et al., 1993).
An indicator species are any biological species that defines a trait or characteristic of the environment. Practically few bacteria, planktons and exotic macrophytes used as indicators for contaminants including nutrient enrichment. The presence or absences of the indicators mirror the actual conditions of water body.

Microbiological examination of water is a direct investigation to find out the deleterious effect of contamination. Bacteria are prokaryotic, single-celled universally occurring microorganism. All natural water contains a blend of pathogenic and non-pathogenic bacteria. It decides the water usage. Thousands of microorganisms reside in a drop of water and transported through it. No one knows the actual number of bacterial species in the world. Most of the native bacteria are detritivorous and are actively engage in biodegradation of organic matter. They carry out constructive process like self-purification of aquatic ecosystem. Anthropogenic activities like frequent bathing of animals, throwing of animal excreta, slaughterhouse waste, septic tank discharges and agricultural runoff (EPA, 2003) are the sources of bacterial population.

Generally, most of the water born bacteria are harmless to humans; however, certain bacteria, some of which normally inhabit the intestinal tract of warm-blooded animals, have the potential to cause sickness and ailment in humans. Water borne diseases form the largest single category of communicable diseases (WHO, 1992). The WHO estimates that worldwide diarrhea diseases alone account for 1.8 million of the 3.1 million water-related deaths per year, mostly in developing countries (WHO, 2004). In India 11.5 % of all water borne communicable diseases, among which diarrhea is most prevalent water borne diseases, responsible for 25-30 % death among children below the age of five years.
The total coliforms are group of large collection of different kinds of bacteria, found in the environment and are habitually harmless. It includes all the aerobic and facultative anaerobic, Gram negative, non-sporulating bacilli that produce acid and gas from the fermentation of lactose with in 48 hrs at 35°C (Pelczar et al., 1993), many of which were not fecal origin. The high coliform count acquire in the samples may be a signal that the water sources are fecally contaminated (EPA, 2003). It is not recommend as an indicator for recreation water. Enterobacter areogenes detect on grains and plants but may exist in human and animal faces (Pelczar et al., 1993).

The fecal coliforms (Enterobacteriaceae) are a subgroup of coli bacteria, thermo tolerant that ferment lactose to produce gas at 44.5°C, fecal specific in origin and used as indicator (APHA, 2005). Escherichia coli are the most commonly known fecal coli bacterium. USEPA recommends the use of E. coli and enterococci as indicators of enteric pathogens in fresh waters. Fecal streptococci are a subgroup of the genus streptococcus, gram-positive, catalase negative, coccoid shaped chain forming bacteria of intestine origin (Pelczar et al., 1993).

Salmonella (Enterobacteriaceae) are rod-shaped, Gram-negative, non-spore-forming, motile bacteria and has been concern in water analysis for more than 100 years (APHA, 2005). Over 2000 serovars of salmonella exist, all of which are pathogenic for humans causing enteric fever, gastro-enteritis with diarrhea (Pelczar et al., 1993, Sodhi, 2002). According to WHO, over 16 million people worldwide infected with typhoid fever each year, with 500,000 to 600,000 fatal cases. Shigella (Enterobacteriaceae) are group of gram-negative, non-spore-forming, facultative intracellular pathogens closely related to Salmonella, which grow in the presence
and absence of oxygen. Genus *Shigella* closely related to *E.coli*, all the strains are pathogenic, causing bacillary dysentery (Pelczar *et al.*, 1993).

*Klebsiella* (Enterobacteriaceae) are lactose fermenting, nonmotile, rod-shaped, gram-negative bacilli. Under certain conditions, they form a gelatinous encapsulation. It can survive for about 20 days in the laboratory conditions, but persist in the environment developed in to a mucoid mutant that dominated over time (APHA, 2005). Patients at high risk are those with impaired immune systems, patients with burns and wounds, those undergoing immuno suppressant therapy or those with HIV/AIDS infection. *Proteus* species (Enterobacteriaceae) are gram-negative bacilli. *Proteus mirabilis* causes urinary tract infection of human. *Proteus* sps belongs to intestinal flora but widely distributed in soil and water ((Pelczar *et al.*, 1993). *Pseudomonas* (Psedomonadaceae) are gram -ve, motile, rods, which are obligate aerobes and oxidize carbohydrates. It is widely distribute in soil and water (Pelczar *et al.*, 1993) and causes a variety of opportunistic infections often causing nosocomial infections.

Bacteria decompose complex organic matter, release much simple substance and CO\(_2\). Phytoplankton utilizes the simple substances and produces organic matter through the process of photosynthesis, release oxygen. Usually water exposed with direct sunlight is ideal for the growth of phytoplankton. Phytoplanktons are microscopic, unicellular, colonial or filamentous, photosynthetic, normal dweller of all surface water ecosystems that shows distinct distribution and diversity (Abdar, 2013). Exuberance growth produce undesirable odour and taste to the water (Pelczar *et al.*, 1993), which will affect the drinking water status. Especially enormous growth of *Dinobryon*, *Peridinium*, *Asterionella*, *Uroglenopsis*, and *Tabellaria*
produce fishy odour, *Aphanizomenon*, *Anabaena*, *Gomphosphaeria*, *Cylindrospermum* and *Rivularia* produce grassy odour, *Cladophora*, *Hydrodictyon*, *Ceratium*, *Aphanizomenon*, *Anabaena* and *Cylindrospermum* produce septic odour (cpheeo.nic.in/).

Phytoplankton diversity responds rapidly to the changes in the aquatic environment particularly in relation to nutrients (Chellappa *et al.*, 2008). Luxurious growth of some algae reduces the hardness of water and removes salts, which are the causes of brackishness (Pelczar *et al.*, 1993). Decomposition of algal cell consumes oxygen (Sodhi, 2002). *Euglena* and *Ocillotaria* are the reliable indicator of eutrophication (Tripathi and pandey, 1990), *Chlorella*, *Microcystis* and *Scenedesmus* may be considered as marker of organic pollution (Aravind kumar, 2002). The entire group of diatoms acts as a bio indicator of oxygen and nitrogen level in water.

Nutrient-rich pools encourages the growth of cyanobacteria, produce toxins that affect animals and humans. Individuals may expose to cyanobacterial toxins by drinking or bathing in contaminated water. *Microcystis*, *Anabaena*, *Oscillatoria*, *Nodularia*, *Nostoc*, *Cylindrospermopsis* and *Umezakia* produced hepatotoxins that affect the liver, *Aphanizomenon* and *Oscillatoria* produced neurotoxins that affect the nervous system (www.who.int/water_sanitation_health/diseases/cyanobacteria/en/).

Algal pollution indices are used to detect and evaluate the level of pollution in water bodies. It developed on the bases of various algal groups, which have different tolerance to organic pollution and nutrient enrichment. Species structure of the sample, their distribution pattern, the presence or absence of indicator organism
provides information for calculating biological indices. Nygaard (1949) proposed five indices (myxophycean index, chlorophycean index, diatom index, euglenophycean index and compound index) to judge the pollution status of water. Cyanophyta, Euglenophyta, centric diatoms and Chlorococals display eutrophic condition but pennate diatoms and desmids signify oligotrophic condition.

Apparent components of all aquatic ecosystems are macrophytes. They play a vital role in maintaining the property of water. They are chief primary producers, which exhibit an obvious seasonal variation in their population. All the surface cells of the submerged aquatic macrophytes are able to assimilate nutrients and dissolved gases directly from the neighboring water. Nutrients accumulation in an aquatic ecosystem starts eutrophication, emerging luxurious growth of aquatic macrophytes.

Exotic weed like *Eichhornia crassipes* is free-floating water plant, native of Amazon basin, and are highly problematic around the ponds in Kanyakumari district, but which are efficiently removed lead, mercury and cadmium (Wolverton *et al.* 1978). Surface floating hydrophytes has tremendous capacity of absorbing nutrients, reducing the infiltration light, changing the temperature, pH, DO levels of water, reducing gas exchange at the water surface and make canopy. Massive growth leads to increasing water loss through transpiration and adversely affects inland fisheries and water transportation. *Hydrilla verticillata* and *Urticularia* are submerged macrophytes entirely grow underwater and form dense mats. Rooted macrophytes often produce distinct zones along the shoreline and are capable to take off nutrients from sediments and water column.
NEED FOR THE PRESENT STUDY

The research area of the present study was predominantly an agricultural zone with dense agricultural activities. During Maharajas period, this land called “Rice granary of Trivancore” because of high rice production. Majority of the people in this province depend on agriculture (i.e. cultivators and agricultural labourers. Both for recreation as well as irrigation purposes substantial amount of surface water is used in this area. Now paddy fields slowly converted to rubber estates. Geographically two sides of the experimental area covered with sea and one side with Western Ghats. Natural saline water intrusion was tremendous near the coastal zone. Fresh water acts a barrier to prevent intrusions. The withdrawal of excess ground water, create alarm situation of saline water intrusion towards the agronomical area.

The present investigation forms the baseline attempt on the status of Pechiparai reservoir water until its depository in Thengapattanam. A number of studies had been carried out on ecological condition of freshwater bodies in various parts of India (Sivakumar et al., 2008; Thirumala et al., 2011; Hulyal and Kaliwal, 2011; Medudhula et al., 2012; Ravikumar et al., 2013; Amruthakalyani and Gangadhar Rao, 2014. However, southern part of Tamilnadu, the ecological studies of freshwater body is very scanty (Sreenivasan, 1965; Murugavel and Pandian, 2000; Sivakumar et al., 2010; Reginold, 2010; Mary Kensa, 2011; Mariy Christi et al., 2011. Madhevan Pillai et al., 2011. However, information on relationship between physico-chemical parameters and biological community is very limited (Murugavel and Pandian, 2000).
In the recent past, anthropogenic pressures on surface water ecosystems have increased tremendously and it had been realized that many species of both plant and animals would be lost prior to the understanding of their utility. Residential waste, toxic chemicals, sewage from rubber processing units, cashew nut factories and agricultural runoff deteriorated the water quality of ponds that received water through a system of canals from Pechiparai reservoir. Keeping the above facts in view, the present research work intends to study the status of water from Pechiparai reservoir until its depository in Thengapattanam estuary and its influence on the ecology and biodiversity of adjacent ponds, with following aims

- **To study the seasonal variation of water quality at five different storage locations from its origin to its dispersal near Thengapattanam.**
- **To assess the contents of water by bacterial and phytoplankton indicators.**
- **To study the diversity of aquatic macrophytes.**