2.0 REVIEW OF LITERATURE

2.1 POND WATER AND ITS PHYSICO-CHEMICAL CHARACTERS AS POLLUTION INDICATORS

The physico-chemical characteristics of water bodies are altered due to heavy discharge of effluents and sewages.

Sangodoyin, (1991) reported that the effluents from industries have a great toxic influence on the pollution of the water body, as they can alter the physical, chemical and biological nature of the receiving water body. According to Shaw et al. (1991) the quality of water is usually determined by its physico-chemical characteristics and it is a well established fact that domestic sewage and industrial effluent discharged into natural water result in deterioration of water quality and cultural eutrophication. Tiwana, (1992) studied on the important sources of water pollution which includes mass bathing, disposal of dead bodies, rural and urban waste matters, agricultural run-off and solid waste disposal.

Gautam et al. (1993) studied on the physico-chemical characters of sewage and its impact on water quality of Alaknada at Srinagar. Correia et al. (1994) observed that the chemical pollutants, which are present in the waste water, arise both from the raw materials and as additives used to produce the finished clothes. Kaushik and Saksena, (1995) reported that the physico-chemical parameters are useful in detecting effects of pollution on the water quality but changes in the trophic conditions of water are reflected in the biotic community-structure including species pattern, distribution and diversity.

Ademoroti, (1996) stated that the effluents contain high amounts of dissolved salts from domestic sewage can increase the salinity of the receiving water, which may result in adverse ecological effects on aquatic biota. Peirce et al. (1997) observed that the most important measure of water quality is the dissolved oxygen. The low level of DO recorded could result in the non maintenance of conditions favourable to the aerobic organisms. This could lead to anaerobic organisms taking over with the resultant creation of conditions making the water body uninhabitable to gill-breathing aquatic organisms.

Aquatic pollution by natural petroleum products now a day is one of the most threatened issues for the aquatic organisms particularly to the fishes occupying the
surface layer, as reported by Khan, (1999). According to Karr et al. (2000) analysis of the physico chemical characteristics of water samples generally provide only a picture of environmental conditions at the moment samples are taken. It provides chemical quality but do not necessarily reflect the ecological state of the system.

Waste water discharge from sewage and industries are major component of water pollution, contributing to oxygen demand and nutrient loading of the water bodies, promoting toxic algal blooms and leading to a destabilized aquatic ecosystem as reported by Morrison et al. (2001). Effluents which are rich in organic and inorganic substances are capable of producing adverse effects on the physical, chemical and biotic components of the environment and either directly or indirectly on human health, which was studied by Ogbeibu and Ezeunara, (2002). Beg et al. (2003) remarked that waste water may become seriously dangerous, leading to the accumulation of toxic products in the receiving water bodies with potentially serious sequences on the ecosystem.

The physical and chemical characteristics of water bodies affect the abundance, species composition, stability, productivity and physiological condition of aquatic organisms. The physico chemical parameters of an aquatic body not only reflect the type and diversity of aquatic biota but also the water quality and pollution, which was reported by Qayoom Mir et al. (2004). Petroleum refinery effluents (PRE) are wastes originating from industries primarily engaged in refining crude oil and manufacturing fuels, lubricants and petrochemical intermediates. These effluents are a major source of aquatic environmental pollution, which was reported by Wake, (2005).

Sachindananda murthy and Yajurvedi, (2006) studied that the physicochemical parameters of a Bilikere lake in Mysore city, Karnataka, India. High DO content might be due to the increased photosynthetic activity facilitated by increased temperature and pH and decreased turbidity.

Bhuiyan and Gupta, (2007) observed that the comparative hydrobiological study of a few ponds of Barak valley, Assam and their role as sustainable water resources. Low range of phosphate value in all the ponds is due to high temperature, phosphate is rapidly assimilated by plankton and microorganisms. Shrivastava et al. (2008) studied that the physicochemical quality of pond water in Bilaspur,
During the present study, BOD levels in the most of the samples were much more beyond the permissible limit, due to these ponds are bearing appreciable high load of bio-degradable organic pollutants.

Lashari et al. (2009) reported that the physicochemical characteristics of Keenjhar lake, District Thatta, Sindh, Pakistan. TDS were maximum in autumn and minimum in winter. This may be due to the size of the water body, inflow of water, consumption of salts by algae and other aquatic plants and the rate of evaporation. Manjare et al. (2010) studied that the analysis of water quality using physicochemical parameters of Tamdalge tank in Kolhapur district, Maharashtra. The high value of phosphate are mainly due to rain, surface water runoff, agriculture runoff, washer man activity could have also contributed to the inorganic phosphate content. Rajagopal et al. (2010) observed that the physicochemical conditions in three perennial ponds of Virudhunagar district, Tamilnadu. High concentration of DO was recorded, which may be due to low solubility at high temperature degradation of organic substances.

Palamthodi et al. (2011) observed that the effluent with high levels of BOD and COD values are highly toxic to biological life. The high alkalinity and traces of chromium, which is employed in dyes adversely affect the aquatic life and also interfere with the biological treatment processes. Rajiv et al. (2012) reported that the comparative physicochemical and microbial analysis of various pond waters in Coimbatore district, Tamilnadu. India. Tidame and Shinde, (2012) reported that the seasonal variations in physicochemical parameters of the temple pond, Nashik District (M.S), India. The highest BOD was recorded during summer due to high temperature favours microbial activity. Idris et al. (2013) reported that the higher level pH, TSS, TDS, COD, phosphate, nitrate and chloride are due to the effect of pharmaceutical effluent in the surface water of River Golax in Minna, Nigeria state, Nigeria.

2.2 BIOASSAY STUDIES IN FISHES

Bioassay plays a crucial role in the understanding of ecosystem functioning, but only as a tool, and more comprehensive studies of contaminated sites should be performed to understand the influence of chemical speciation and environmental factors on the toxicity of environmental pollutants.
Toxicity tests have been conducted using various toxicants and reported by many authors. Dhanapal et al. (1990) studied the toxicity of tannery effluent on the fish, *Sarotherodon mossambicus*. Ghatak and Konar, (1991) reported that sublethal concentration of petroleum hydrocarbons have significant effects, which can lead to physiological dysfunctions in the fish. Ramalingam et al. (1992) determined the median lethal tolerance limit for 96 hour LC50 of five different toxicants by renewal static methods.

Acute toxicity of tannery effluent to the common carp, *Cyprinus carpio* Var. communis was studied by Arunkumar et al. (1993). Ambrose et al. (1994) observed the (LC50) of toxic stress of sublethal concentration of composite tannery effluent in the fish, *Cyprinus carpio*. Sublethal concentration of toxicants in the aquatic environment will not necessarily results in out right mortality of aquatic organism as documented by Omoregie, (1995). Effect of acute doses (LC50) of Chromium on fish, *Cyprinus carpio* was studied by Al-Akel, (1996). The acute toxicity of two Organophosphorus pesticides, Nuvan and Dimencron to the fresh water murrel, *Channa orientalis* (Schndider) was determined by Saxena et al. (1997) by conducting static renewal bioassay experiments.

Short term static bioassays were carried out by Raizada and Rana, (1998) to evaluate the toxicity of Malachite green, a very common multipurpose dye stuff on a commercial teleost fish, *Clarias batrachus*. Acute toxicity bioassays (LC50) are conventional tools and very extensively used to assess the potency toxicity of physiologically active heavy metals and also to evaluate the full potential of metal contamination on commercially and ecologically important species as reported by Samina and Muzammal, (1999).

Bioassay tests were conducted by Trivedi and Saksena, (1999) to determine the acute toxicity of an Organophosphorus pesticide, Nuvan to the fresh water fish, *Clarias batrachus*. Maruthi and Subba Rao, (2000) recorded the LC50 of distillery effluent in the fish, *Channa punctatus*. Ganesh et al. (2000) studied the effect of acute toxicity of copper on three life stages of common carp, *Cyprinus carpio* and worked out the 96 hour LC50 value. Variations in the acute toxicity of Endosulfan and monocrotophos to *Labeo rohita*, *Mystus vittutus* and *Channa punctatus* was evaluated by Rao and Ramaneswari, (2000).

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Toxicity levels of industrial effluents in Taiwan were studied using *Tilapia mossambica* by Chen et al. (2001). Srivastava and Srivastava, (2002) recorded LC$_{50}$ of Cadmium chloride in the fish, *Heteropneustes fossilis*. According to Datta and Kaviraj, (2003) the determination of toxic compounds presents in the aquatic environment and its effect on aquatic organisms is a basic issue in aquatic toxicology.

Mathivanan, (2004) reported on the toxicity of Quinalphos on alkaline phosphatase activity in *Oreochromis mossambicus*. Venkataramana et al. (2004) reported on the gobiid fish, *Glossogobius giuris* which was exposed to sub lethal concentrations of (0.05, 0.25 and 0.5 ppm) Organophosphorus pesticide, Malathion for short duration (24 to 96 hr). A Bioassay study for effluents from waste water treatment plants provides a complete response of test organisms to compounds present in waste water and to understand the discharge capacity of the raw and treated waste water as reported by Movahedian et al. (2005).

Pandey et al. (2005) conducted 96-hour acute toxicity tests in flow-through systems to determine the lethal toxicity of Mercuric chloride and Malathion to air breathing teleost, *Channa punctatus*. Verma et al. (2005) conducted the bioassay of dyeing effluent for 96 hour LC$_{50}$ in *Clarias lazera* according to the graphical interpolation method. Naskar et al. (2006) and Madoni and Maria, (2006) measured the susceptibility and surviving potential of fish to particular toxic substances such as heavy metals. According to them to establish the discharge standards for pollution in the environment, it is important to study their toxicity on common flora and fauna of the area.

Murat Pala et al. (2006) studied the acute toxicity of Organophosphorous pesticide, diazinon and its effects on fingerlings of European catfish, *Silurus glanis* L. Muley et al. (2007) carried out acute toxicity (96 hours) experiment in fingerlings of fresh water fish, *Labeo rohita* which was exposed to tannery, electro plating and textile mill effluents. Yadav et al. (2007) reported on the toxicity of fertilizer’s industrial waste water on snake head fish, *Channa striatus* (Bloch) previously named as *Ophiocephalus sp.*, at different concentrations viz., 20, 40, 60, 80 and 100 percent on the behavioural changes and mortality. In the acute toxicity of contaminants in static bioassays, the use of 96-hour LC$_{50}$ has been widely
recommended as a preliminary step in toxicological studies on fishes, which was reported by Moreira et al. (2008).

Zodape, (2010) studied on the effect of Aloe vera juice and chromium on Labeo rohita fingerlings exposed to sub-lethal concentration of Chromium and Aloe vera juice for 21 days. According to Ogundiran et al. (2010) the toxicity of commercial detergent effluent in the median lethal concentration (LC50) values for lethal and sublethal tests were (0.0166 mg/L and 0.0038 mg/L) present in the juvenile of African Catfish, Clarias gariepinus. The toxicity of sodium cyanide to the freshwater fish, Labeo rohita was studied using static bioassay method of LC50 in 96 hour by Prashanth et al. (2011). Ganeshwade, (2011) studied on the freshwater fish, Puntius ticto which was exposed to lethal (5.012 ppm) and sublethal (2.50 ppm and 1.253 ppm) concentration of Dimethoate for 96 hours and 60 days durations.

Alireza Safahieh et al. (2012) observed the sub-lethal effects of a herbicide, Paraquat (96 hours) on LC50 concentration in the fish, Mesopotamichthys Sharpeyi. Nikalje et al. (2012) reported on the fingerlings of Labeo rohita which were exposed to acute (96 hour) and chronic (30 days) dose of textile mill effluent. Acute toxicity of pesticide (Monocrotophos and Lambda cyhalothrin) on the fresh water fish, Labeo rohita was studied by Muthukumaravel et al. (2013).

2.3 EFFECT OF POLLUTANTS ON BIOCHEMICAL COMPOSITION

Alterations of carbohydrate metabolism have been observed in Tilapia mossambica exposed to fenvalerate by Radhaiah and Rao, (1990). Rajan, (1990) recorded that protein, carbohydrate and lipid contents decreased significantly in muscle, liver and intestine of Cyprinus carpio when exposed to sublethal concentrations of textile mill effluent. Alteration in the protein and lipid contents of intestine, liver and gonads in the lead exposed fresh water murrel, Channa punctatus (Bloch) was observed by Jha, (1991). James et al. (1991) have investigated significant decrease in protein, carbohydrate and lipid in muscle, liver, gill and the whole body of Oreochromiss mossambicus exposed to metals individually and in combinations.

Effect of sublethal concentrations of pesticides namely DDT, Endosulfan and BHC on carbohydrate metabolism in Sarotherodon mossambicus was studied by Ramalingam et al. (1992). Joseph et al. (1992) studied the effect of toxicity of nickel on protein content in the tissue of fish, Cyprinus carpio.
Agarwal, (1992) observed that an elevated level of serum cholesterol in *Channa punctatus* exposed to mercuric chloride effluent might be an indication of liver damage, which normally esterifies cholesterol and excrete a part of it with the bile. Analysis of biochemical parameters could help to identify target organs of toxicity as well as the general health status of animals. It may also provide an early warning signal in stressed organism as reported by Folmar, (1993). Phenol induced metabolic alterations in the brain and muscle of fresh water fish, *Channa punctatus* during sublethal toxicosis was reported by Reddy *et al.* (1993).

A significant decrease in the carbohydrate content of the muscle and liver in *Mystus vittatus* exposed to different industrial effluent was studied by Sivakami *et al.* (1994). Ambrose *et al.* (1994) observed decline in lipid contents of gill, liver, intestine and kidney of *Cyprinus Carpio* under the toxic stress of sublethal concentration of composite tannery effluent. Sublethal dose of mercuric chloride administered to a fresh water fish, *Channa punctatus* for a period of four weeks brought about significant haematological and biochemical abnormalities in blood, liver and muscle, which was observed by Shakoori *et al.* (1994). The depletion in the hepatic total lipid could be due to their active mobilization towards the blood and tissue metabolism as reported by Murthy *et al.* (1994).

The concentration of total cholesterol and total lipids in serum and tissues of fish have been reported to be moderately sensitive to environmental pollutant but the direction of change in these parameters seems to be dependent on many factors, such as the types of contaminant, the concentration, mode of its action, duration of exposure and fish species, which was studied by Heath, (1995).


A significant decrease of protein concentration following an acute effect of fenitrothion in the eel was reported by Sancho *et al.* (1997). Virk and Kaur, (1998) observed biochemical alterations in the gonads of *Cyprinus carpio* L. exposed to
mixture of nickel and chromium. Kapila Manoj and Ragothaman, (1999) have studied the changes in protein level in muscle tissues of *Bolephthalus dussumieri* due to exposure of mercury, copper and cadmium. Virk and Sharma, (1999) have studied the biochemical changes induced by nickel and chromium in the liver of *Cyprinus carpio* and observed significant decline in the cholesterol content of liver.

Decrease in glycogen, total proteins and lipids with increasing concentration of distillery effluent indicate a decrease in energy supply metabolism through oxidative pathways, which ultimately lead to less growth in the fish, *Channa punctatus* as reported by Maruthi and Subba Rao, (2000). Aruna Khare *et al.* (2000) reported that the sublethal concentrations of malathion showed a significant increase in the protein content, which on prolonged exposure decreased gradually.

Yeragi *et al.* (2000) observed decreased levels of proteins in gills, testis, ovaries and muscles of marine crab, *Uca marionis* exposed to acute and chronic levels of malathion. Impact of distillery effluent on biochemical consequences in the fresh water teleost, *Channa punctatus* was studied by Kumar and Gopal, (2001). Choudhary and Gaur, (2001) observed a decline in liver protein of *Cyprinus carpio* under sodium fluoride stress. Rawat *et al.* (2002) have reported continuous decrease in the quantity of glycogen in the liver of *Heteropneustes fossilis* exposed to endosulfan. Variation in lipid, protein and carbohydrate content during the embryonic development of the cray fish, *Cherax quadricarinatus* was observed by Marcelo *et al.* (2003).


Carbohydrates in the tissues of animals exist as protein bound sugars and glycogen. Protein bound sugar is the best energy producers of the body of the living organism. Polysaccharides occur both in free-state as well as bound state along with
proteins. Chemical stress causes rapid depletion of stored carbohydrates primarily in hepatopancreas and in other tissues which was studied by Vijayavel and Balasubramanian, (2006).

Shobha et al. (2007) reported on the decrease in protein, glycogen and lipid contents in the liver of fresh water fish, *Catla catla* under Cadmium chloride stress. According to Vivian et al. (2007) there is an increase in plasma glucose when the fish, *Prochilodus lineatus* is exposed to the herbicide glyphosate, which shows the typical stress response. Protein, lipid and carbohydrate are involved in major physiological events, therefore assessment of their content can be considered as a diagnostic tool to determine the physiological phase of organism was studied by Martin and Arivoli, (2008). Majumdar et al. (2008) studied on the carbohydrate content in the muscle of *Heteropneustes fossilis* exposed to Galvanizing industry effluent. Tiwari and Singh, (2009) observed decrease in total protein and glycogen in the liver of *Colisa fasciatus*, exposed to ethanolic extract of *Nerium indicum* mill latex. Alterations in biochemical profile of liver and ovary in zinc-exposed fresh water murrel, *Channa punctatus* (Bloch) was studied by Neera Srivastava and Hemlata Verma, (2009).

Barad and Kulkarni, (2010) reported on the blood serum biochemical components like, Hb, proteins, cholesterol and glucose level in the *Notopterus notopterus* due to stress caused by copper concentrations. Ayre Bahar Yilmaz et al. (2010) studied on the uptake and distribution of hexavalent chromium in tissues like gill, skin and muscle of a fresh water fish, Tilapia *Oreochromis aureus*. Cholesterol level increases in kidney, this may be due to liver disfunction and cholesterol is accumulated or shifting towards kidney. Similar results were observed by Ganeshwade, (2011). Haematological, biochemical and enzymological parameters of blood in the fish, *Cirrhinus mirgala* acts as biomarkers in monitoring the level of toxicity in the aquatic organisms, which was studied by Saravanan et al. (2012). According to Hyalij, (2013) on exposure to sub lethal concentration of sugar factory effluent, the biochemical changes in the tissues of fish, *Lepidocephalous thermalis* showed initial increase but gradual decrease with time exposure at 96 hours.
2.4 EFFECT OF POLLUTANTS ON HAEMATOLOGY

Since haematological parameters reflect the poor condition of fish more quickly than other commonly measured parameters and the fish respond quickly to changes in environmental conditions and widely used for the description of healthy fish for monitoring stress responses and for predicting systematic relationships and the physiological adaptations of animals.

Gill et al. (1990) recorded a decrease in erythrocytes count in the blood of *Punctius conchonicus* after exposure to pollutants. MCV and MCHC levels increased in *Oreochromis mossambicus* when exposed to cadmium as reported by Ruperalia *et al.* (1990). Houston and Murad, (1991) observed various haematological parameters in response to thermal acclimation and heat shock in *Carassius auratus*.

The use of haematological variables as indicators of stress, toxic substances as well as metals can provide information on the physiological response that fishes make to a changing external environment was reported by Vander Merwe, (1992). Saxena and Chowhan, (1993) observed a decrease in the number of erythrocytes, leucocytes and depletion of haemoglobin content in *Cyprinus carpio* when subjected to thermal stress. Haematological parameters are used as tools for assessing the health of fish as reported by Sampath *et al.* (1993). According to Omorogie *et al.* (1994) changes in haematological parameters are quick responses to environment or physiological alterations. They are easy to measure and can provide an integrated measure of the physiological status of the organisms.

Sampath *et al.* (1993) and Omorogie *et al.* (1994) reported on the reduction of leucocytes, erythrocytes, haematocrit, Hb and MCV of fish, *Nile tilapia* exposed to polluted environment under laboratory conditions. Harmful effects on animals and fish exposed to pollution have been reported by Borepubo *et al.* (1994). Tiwari, (1995) reported that the fungicides affect the haematological parameters in fish. Mourad, (1995) recorded an increase of Hb content in *Tilapia zilli* exposed to copper works effluent for 14 days.

Blood parameters are used in order to diagnose and describe the general health condition of fish. This type of index reflects certain ecological changes in the environment as reported by Roche and Boge, (1996). Sekar and Christy, (1996) recorded significant increase in number of WBC in cat fish, *Mystus* exposed to
sublethal concentration of Phosphamidon. MCV and MCH along with MCHC showed appreciable decrease in exposed fishes, which clearly indicate the hypochronic microcytic anaemia.

Nounou et al. (1997) found that RBC, Hb, and PCV decreased in Channa punctatus and Clarias lazera exposed to heavy metals. Wepener, (1997) suggested that the haematology, biochemical changes, growth rate and oxygen consumption of fish can be used in determining the toxicity of pollutants.

Luskova, (1998) and Omorogie, (1998) studied that the assessment of physiological parameters such as cortisol, glycemia, ion concentration, red blood cells, haemoglobin and haematocrit offer responses to toxicant stress. Wahbi, (1998) observed that Sparus auratus and Solea vulgaris exposed to industrial effluents showed haemolytic anaemia accompanied by leucocytosis. The sublethal effects of various heavy metals on the haematology of Clarias sp. was studied by Kori-Siakpere and Egor, (1999).

Significant increases in the haemoglobin concentration and the number of the haematocrit were found in Carassius auratus gibelio and they were attributed to the toxic effects of textile dyes which was studied by Al-Sabti, (2000). According to Ray and Dubey, (2001) the increased PCV, MCV may be considered as a combined effect of erythrocyte swelling and compensative mechanism of the fish to increase the oxygen carrying capacity of the blood.

Haematological changes in fish may be used for assessing the effects of contaminants, because blood parameters respond to low doses of pollutants as reported by Affonso et al. (2002). Saxena and Seth, (2002) showed a significant change in the haematology of the common fresh water fish, Channa punctatus on exposure to pyrethroid. Gautam and Gautam, (2002) observed decrease in RBC, Hb content and increase in WBC of blood in Channa striatus treated with endosulfan and diazinon. Davids et al. (2002) observed significant haematological changes in two tilapine species, Sarotherodon melanotheron and Tilapia guineensis, from adjoining rivers receiving treated effluents from the National Fertilizer Company, NAFCON and a nearby petrochemical company.

Navaraj and Kumaraguru, (2003) observed that the fish, Oreochromis mossambicus exposed to electroplating effluent induced haematological changes with
the increase in time of exposure and concentration of the effluent. Shah and Altindag, (2004) have reported decrease in Hb, RBC count and haematocrit in the fish, *Tinca Tinca* exposed to mercuric chloride and lead. Effluents released from various industries have been a major concern in causing aquatic pollution and a considerable number of researchers have been done on blood parameters of fish to determine the effects of effluents from petroleum refinery in *black Goby* as reported by Selma and Hatice, (2004).

Udayakumar, (2005) studied the fish, *Clarias batrachus*, which exposed to treated dairy effluents showed an increase or decrease in RBC, Hb, HCT, MCV, MCH and MCHC values, but blood platelets was found to be low. Ramesh, (2006) studied haematological parameters in the *Clarias batrachus* exposed to treated sago effluent and revealed the elevation and declining trend in RBC, HCT, MCH and MCV. Shasikumar and Nagarajan, (2007) reported on the alterations in the haematological parameters in the fish, *Clarias batrachus* exposed to different concentration of treated dairy effluent which may be due to physiological stress caused by the presence of high TDS, alkalinity, chloride and sodium in the effluent.

According to Maheswaran et al. (2008) the blood parameters are important in diagnosing the structural and functional status of fish exposed to toxicants. The decrease in the RBC, Hb, PCV and MCV concentration was reported by Benarjee et al. (2009) in the fish, *Channa punctatus* on exposure to Rayon industrial effluents. A decreased blood cholesterol of *Tilapia mossambica* exposed to detergent surf excel was observed by Shanthi et al. (2009). Majumdar et al. (2010) studied on the effect of galvanizing industry effluent on the haematological parameters of *Heteropneustes fossilis*. Analysis of haematological and biochemical profiles of blood are widely used as indicators to assess the toxic stress, functional status of the animal health and the internal environment of the organism as reported by Li et al. (2011) and Lavanya et al. (2011).

Poonam Gupta, (2012) studied a decrease in haemoglobin percentage in *Colisa faciatus* exposed to Azodyes. Alireza Safahieh et al. (2012) recorded on the sublethal effects of herbicide paraquat on haematological parameters of benny fish, *Mesopotamichthys Sharpeyi*. It is suggested that the paraquat exposure might produced adverse effect on blood parameters of fish, which resulted in anaemia. This condition may affect normal growth, reproduction, immunity and survival of fish in
Both natural and culture conditions. Olaniyi Christiana et al. (2013) studied the effect of cassava mill effluent on haematological characteristics of Adult African catfish, *Clarias gariepinus* which showed decreased levels of Hb, RBC and PCV when compared to control.

**2.5 EFFECT OF POLLUTANTS ON BIOCHEMICAL CHANGES IN BLOOD**

Blood provides an ideal medium for toxicity studies. The haematological parameters have been considered as diagnostic indices of pathological conditions in animals. Fish blood can serve as a valuable tool in detecting physiological changes taking place in animal.

Biochemical and haematological variables of blood are given much importance, when clinical diagnosis of fish was applied to determine the effects of external stressors and toxic substances. Researchers in the field of toxicology consider blood as a vital tissue to understand the acute and chronic toxicity of a material.

Somnath, (1991) observed that the decrease in protein level may be due to stress in fish as protein is likely to undergo hydrolysis and oxidation through TCA cycle to meet the increased demand for energy caused by the stress. According to Mayer et al. (1992) measurement of serum glucose, protein and lipids are useful for understanding toxic effects of chemicals in controlled laboratory conditions. Sampath et al. (1993) observed that haematological studies in fish, lies in the possibility that the blood will reveal anomaly within the body of the fish long before there is any outward manifestation of symptoms of disease or effects of unfavourable environmental factors. Haematological parameters are also used as tools for assessing the health of fish as reported by Omoregie et al. (1994).

The elevated blood glucose levels reflect an increase in the rate of transportation of glucose probably from the liver to muscle where high energy demand was met due to brisk and erratic movements, which was studied by Ravichandran et al. (1995). According to Heath, (1995) the concentration of total cholesterol and total lipids in the serum of fish have been reported to be moderately sensitive to environmental pollutant but the direction of change in these parameters seems to be dependent on many factors, such as the types of contaminant, the concentration, mode of its action, duration of exposure and fish species.
Shakoori et al. (1996) studied the effect of sublethal doses of fenvalerate on the blood, liver and muscles of fish, Ctenopharyngodon idella and observed decreased level of cholesterol. Wepener, (1997) suggested that the haematology, biochemical changes, growth rate and oxygen consumption of fish could be used in determining the toxicity of pollutants. Fish blood reflects pathophysiological status and its parameters are important in diagnosis of the structural and functional status of fish exposed to toxicants as reported by Sampath et al. (1998).

Balasubramanian et al. (1999) observed a significant decrease in blood plasma cholesterol level in Oreochromis mossambicus when exposed to Urea. Alterations in blood glucose levels have been reported in Heteropneustes fossilis exposed to sublethal concentration of testosterone for 30, 50, and 70 days by Chowdhury, (2000). Haematological techniques have been used to determine the sub lethal effect of the pollutants during the clinical diagnosis of fish physiology as studied by Bhagwunt and Bhikajee, (2000).

Haematological study of fish on exposure to pollutants brought knowledge that erythrocytes are the major and reliable indicators of various sources of stress as reported by O’neal and Weirich, (2001). Changes in the biochemical blood profile indicates changes in metabolism and processes of the organism resulting from the effect of various pollutant and they make it possible to study the mechanisms of the effect of various pollutants as reported by Luskova et al. (2002).

Fish blood is sensitive to pollution-induced stress and changes on the haematological parameters, such as haemoglobin content, haematocrit and number of erythrocytes can be used to monitor stress caused by pollutants such as heavy metals was studied by Romani et al. (2003). Effect of sugar factory effluent on glycogen, protein and free amino acids content in tissues of the fish, Lepidocephalus thermalis was studied by Sonawane, Pawar and Hyalij, (2004). Shah and Altindag (2004) studied that fish blood gives the possibility that fish blood will reveal conditions within the fish long before there is an outward manifestation of diseases.

Effects of toxicants on haematological changes in the fish, Clarias gariepinus on exposure to sublethal concentrations of Derris elliptica root was reported by Akinbulumo, (2005). Haematological and biochemical parameters are used as indicators in the measurement of health conditions and toxicological symptoms of
organisms as reported by Venkateswara Rao, (2006). Haematological and blood biochemical studies on textile effluent toxicity in the *Gaumbia affinis* was carried out by Pratimal et al. (2006).

Ajani et al. (2007) studied that the responses of fish to particular stressor vary according to their characteristics, however there are features of stress reaction common to the majority of the forms of environmental stressors, which are known to alter their blood characteristics thereby leading to disruptions in metabolic activities. Rekha Rani et al. (2008) observed hyperglycemia in fish. The increase in the blood sugar level might be due to stimulation of the cells of islet of Langerhans to induced increase in circulatory catecholamines in fish.

Blood parameters are considered as good physiological indicators of the whole body conditions and therefore can be used in diagnosing the structural and functional status of fish exposed to toxicants as investigated by Seriani et al. (2009). Fish blood parameters have been increasingly employed in environmental monitoring programs to indicate physiological changes due to toxicants as investigated by Zutshi et al. (2009).

A significant decrease in the glycogen of brain, gill and muscle was noticed in the fresh water cat fish, *Mystus vittatus* on exposure to heavy metal Mercuric chloride by Kannan et al. (2010). Barad and Kulkarni, (2010) studied the reduction in the blood serum biochemical components like Hb, proteins, cholesterol and glucose level in the fish, *Notopterus notoptreus* on exposure to copper concentrations.

The haemotological and biochemical changes in the teleost fish, *Oreochromis mossambicus* on exposure to textile mill effluent was studied by Poornima et al. (2011). Haematological, biochemical and enzymological parameters of blood in the fish, *Cirrhus mirgala* as biomarkers in monitoring the level of toxicity in the aquatic organisms was studied by Saravanan et al. (2012). Saroja et al. (2013) studied that *Cyprinus carpio* exposed to sublethal concentration of raw distillery effluent showed an overall increase in the blood glucose at all periods of exposure, thereby indicating that the glycogen is being slowly converted into glucose.

**2.6 EFFECT OF POLLUTANTS ON ENZYMES**

Enzymes play an important role in metabolism. They are exceedingly efficient and very specific in terms of nature of reaction catalysed and the substrate utilized.
The synthesis and final concentration of enzymes is under genetic control and is greatly influenced by very small molecules of substrate.

Subbo Rao and Rajender, (1990) reported that the GOT and GPT are two key enzymes known for their role in the utilization of protein and carbohydrate. Any change in the protein and carbohydrate metabolism causes change in GOT and GPT. Lakshmi et al. (1991) observed that the ATP as a membrane bound enzyme plays a key role in the active transport system and is highly sensitive to mercury compounds. Gill et al. (1991) studied that the exposure of *Clarias gariepinus* to sublethal concentrations of cypermethrin showed altered enzyme activities.

Goel et al. (1992) reported that the reduced activities of AST, ALT, ACP, ALP and LDH in various organs of fish, *Pontius conchonius* exposed to mercury in various organs implies destruction in the tissues of the animals. Srinivas, (1993) observed the activity of ICDH in the various tissues of *Clarias batrachus* exposed to endosulfan. Srinivas Reddy et al. (1993) reported on the brain LDH level in *Channa punctatus* on exposure to Hexachlorocyclohexane for 15 days.

Sastry and Gupta, (1994) have demonstrated the increased activities of glutamate oxaloacetate transaminase and glutamate pyruvate transaminase in blood, liver and muscle of fish, *Channa punctatus* exposed to monocrotophos. Bhatnagar et al. (1995) observed a decrease in Acid phosphatase activity in liver and muscle of *Clarias batrachus* on exposure to pyrethroid for 30 days. According to Saxena and Chauhan, (1996) the reduction in oxygen consumption in *Labeo rohita* exposed to effluent was because of coagulation in gill mucus, which has resulted in asphyxiation as well as inhibition of enzyme in mitochondrial level due to toxic compounds in the effluent.

Jothi and Narayan, (1997) reported on the increased activities of glutamate oxaloacetate transaminase (GOT) and glutamate pyruvate transaminase (GPT) in the tissues of fresh water fish, *Clarias batrachus* on exposure to Phorate. Sivakumari et al. (1997) reported on the increased levels of acid phosphatases on continuous exposure of *Cyprinus carpio* to cypermethrin. Shukla and Sastry, (1998) demonstrated increasing activity of GOT and GPT in the effluent treated fish, which is due to increased rate of proteolysis in the tissue. Sambasiva Rao, (1999) reported an elevation in free amino acids and protease activity due to pesticide-induced hypoxia.
De la Torre et al. (2000) showed increased activity of GOT and GPT in response to cadmium and assessed the impact of long-term exposure to waterborne cadmium in the fish, *Cyprinus carpio*. Chen et al. (2000) reported on the significant rise in serum LDH activity after liver damage and referred the augmentation due to muscle LDH release into the blood circulation.

According to Karuppasamy, (2001) increased LDH activity has been reported in different tissues of liver, muscle, intestine, kidney, gill and brain of *Channa punctatus*, when exposed to low and high concentration of phenyl mercuric acetate for short and long-term exposure. A decrease in lactate dehydrogenase in muscle and liver of *Heteropneustes fossilis* due to starvation was reported by Devid kardong et al. (2002).

The decrease in ALP in the various organs in the fish may be attributed to such factors as a decline in the rate of synthesis caused by lowered metabolic demands and also due to electrolytic imbalance caused by tissue over hydration, which was studied by Anderson et al. (2002). Achuba and Osakwa, (2003) reported on a dose dependant increase in the activity of catalase, an oxidant in the liver and other organs of *Clarias gariepinus* exposed to crude oil.

Adhikari et al. (2004) reported that the fresh water fish, *Labeo rohita* on exposure to cypermethrin for 45 days showed altered enzyme activities and haematological changes, Acid phosphate was unchanged, while alkaline phosphatase was depleted. Das et al. (2004) showed that there was an elevation in activity level of AST, ALT and ATP of Indian major carps exposed to nitrite toxicity and suggested that the elevation of the transferases is the result of the diversion of the alpha amino acids in the TCA cycle as keto acids to augment energy production.

Begum, (2005) observed a decrease in total proteins and an increase in free amino acids, protease, alanine aminotransferase, and aspartate aminotransferase in the liver and gill tissues of *Clarias batrachus* exposed to sublethal concentrations of cypermethrin. Venkateshvara Rao, (2006) observed increased activities of acid phosphatase and alkaline phosphatase in plasma, gill, kidney and liver of *Oreochromis mossambicus* exposure to organophosphorous insecticide.

Acid phosphatase, glutamic oxaloacetic and glutamic pyruvic transaminases are commonly used as biomarkers of environmental pollution. Acid phosphatase was
used to estimate the effect of heavy metal pollutants as indicated by the analysis of water samples and gills of *Cyprinus carpio*, which was studied by Ozmen et al. (2006). Yildirim et al. (2006) observed that the increase in enzyme activities (AST and ALT) in the gill, liver and kidney and enzyme elevation is intended to increase the role of proteins in the energy production during toxicant stress in the fish, *Oreochromis niloticus* on exposure to deltamithrin for 4 days.

Shweta Agrahari et al. (2007) reported that the LDH is an important glycolytic enzyme in biochemical systems and is inducible by oxygen stress. The significant decline of lactate dehydrogenase activity in *Channa punctatus*, blood plasma further suggest the decrease in the glycolytic process due to the lower metabolic rate as a result of monocrotophos exposure. Hend Rashad and Nevin sharaf, (2008) reported on the elevation of transaminase activity in *Oreochromis niloticus* on exposure to lead.

Shanthi et al. (2009) observed the increased activities of glutamate oxaloacetate transaminase and lactate dehydrogenase in the liver of *Labeo rohita* on exposure to industrial effluent. Li et al. (2009) observed carbamazepine inhibited AST and ALT activities in the muscle, liver, gills and kidney in the fish, rainbow trout. Sevket et al. (2010) have demonstrated the activities of alkaline phosphatase and lactate dehydrogenase in the blood of the fish, *Cyprinus carpio* from Bafra fish lakes. Abdul Naveed et al. (2011) reported that the increased activities of glutamate-oxalacetate, glutamate-pyruvate transaminase, acid and alkaline phosphatase of blood plasma indicated hepatic tissue damage. Decrease in lactate dehydrogenase content in plasma further indicated lower metabolic rate after 96 hours of exposure of Triazophos in the fish, *Channa punctatus*.

Gabriel et al. (2012) observed the effects of sublethal levels of cypermethrin on metabolic enzymes such as Aspartate transaminase, Alanine transaminase, Alkaline phosphatase and Lactate dehydrogenase in the organs of African cat fish, *Clarias gariepinus*. The enzyme activities in all the organs were inhibited by different levels of cypermethrin concentrations, with ALP activity being mostly affected. Magar and Afsar sheikh, (2013) observed a decrease in acid phosphatase activity in liver and muscle of *Channa punctatus* on exposure to Malathion.
2.7 EFFECT OF POLLUTANTS AND THE HISTOLOGICAL ALTERATIONS

Histopathological changes in animal tissues are powerful indicators of prior exposure to environment stressors and are net result of adverse biochemical and physiological changes in an organism. For field assessment histopathology is often the easiest method for assessing both short and long term toxic effects, which was reported by Hinton and Lauren, (1990).

Onwumere and Oladimeji, (1990) reported on the accumulation of heavy metals with accompanying histopathology in Oreochromis niloticus exposed to treated petroleum refinery effluent from the Nigerian national petroleum corporation, Kaduna. Any change in water quality is rapidly reflected in fish gill structure and function, since gills are continuously exposed to ambient water. Gills are the primary sites of gas exchange, acid-base regulation and ion transfer as reported by Randall, (1990).

Histological changes in the kidney after exposure to different concentrations of the effluent included shrinkage and damage of glomerulus. In addition, the tubular epithelium was desquamated, vacuolated and often destroyed. Dilation of the lamina of the kidney tubules, necrosis of tubules, shrinkage of glomerular tuft and vacuolation of blood cells in the glomerular tuft have been reported in Heteropneustes fossilis exposed to chlorpyrifos, which was studied by Srivastava et al. (1990).

According to Roy and Datta, (1991) inflammatory alterations of lamellar epithelium and hyperplasia were reported in the gills of fresh water carp, Cirrhinus mrigala (Hamilton) during 48 hours exposure to sublethal dose of Malathion. Pundir et al. (1992) studied on the chronic toxic exposure of cadmium on the pituitary gland of fish, Puntius ticto and pattern of recoupment.

Murugeson et al. (1992) reported on the histopathological and histochemical changes in the oocytes of the air breathing fish, Heteropneustes fossilis (Bloch) exposed to textile mill effluent. Increased branchial diffusion distance has been attributed to elevated mucous secretion in the Antarctic fish, Pagothenia borchgrevinki exposed to the WSF (water soluble fraction) fuel oil as reported by Davison et al. (1993).

Banerjee and Bhattacharya, (1994) observed that the Elsan treatment in Channa punctatus resulted in a significant decrease in the dimension of Bowman’s
capsule and glomerulus and the tubules lost their regular shape due to precipitation of cytoplasm and karyolysis. Omorogies, (1995) reported that sublethal concentration of Petroleum products led to the destruction of gill epithelium.

Histopathological changes in the gill of *Labeo rohita* were reported by Vijayalakshmi and Tilak, (1996) which included epithelial proliferation, congestion of blood vessels and hyperplasia. Lactate dehydrogenase release from the liver after its cellular damage and failure due to organophosphate insecticide intoxication was reported by Ceron *et al.* (1997).


Gills are the target of waterborne pollutants due to the constant contact with the external environment, as well as the main place for copper uptake as reported by Campbell *et al.* (1999). The structural alteration induced by chromium in the gill of *Labeo rohita* was reported by Sesha Srinivas, (1999).

The moderate histopathological alternation in gonads of *Channa punctatus* exposed to paper mill effluent was reported by Sayeed *et al.* (2000). Alterations in the size of nucleus in *Brachydanio rerio* exposed to sublethal concentrations of copper sulphate was studied by Paris-Palacios *et al.* (2000). Erkmen *et al.* (2000) reported on the lifting of epithelial layer from gill lamellae, necrosis and degeneration of secondary lamellae, shortening of secondary lamellae and club-shaped lamellae in the gills of *Lepistes reticulatus* exposed to cyphenothrin.

Dass and Mukherjee, (2000) reported on the dilation of tubules, necrotic changes characterized by karyorrhexis and karyolysis in the nuclei of affected cells of *Labeo rohita* exposed to hexachlorocyclohexane. Peris and Kalaiarasi, (2001) studied on the histopathological response of catfish to chronic and acute toxicity of an organophosphate pesticide and found that the histopathological changes revealed that defense reactions occur in the fish to resist the pesticide.

Koponen *et al.* (2001) stated that histopathological study of bream (*Abramis brama*) and asp (*Aspius aspius*) living in a PCB (Polychlorinated biphenyl)-polluted
freshwater lake revealed abnormal cellular changes in the renal corpuscle of both species, dilation of glomerular capillaries, mesangial edema, an adhesion between visceral and parietal layers of Bowman’s capsule and filling of Bowman’s space. Histopathological effects of sublethal concentration of monocrotophos on the gills of *Anabas testadineus* was reported by Santhakumar *et al.* (2001).

According to Esther *et al.* (2001) gills are the major respiratory organs and all metabolic pathways depend upon the efficiency of the gill for their energy supply and damage to these vital organs causes a chain of destructive events, which ultimately lead to respiratory distress.

Histopathological lesions induced by copper sulphate and lead nitrate in the gills of fresh water fish, *Nandus nandus* was reported by Sarita khare and Sudha singh, (2002). Jiraungkoorskul *et al.* (2002) reported on the histopathological changes in the liver and gills of Nile tilapia, *Oreochromis niloticus* exposed to glyphosate herbicide. In the gills, filamentous cell proliferation, lamellar cell hyperplasia, lamellar fusion, epithelial lifting and aneurysm were observed. In liver, there were vacuolations of hepatocytes and nuclear pyknosis.


According to Iqbal *et al.* (2004) the kidney is a vital organ of body and proper kidney function is to maintain the homeostasis. It is not only involved in removal of wastes from blood but it is also responsible for selective reabsorption, which helps in maintaining volume and pH of blood and body fluids and erythropoieses.

Van Dyk *et al.* (2005) reported that the sublethal levels of metal mixtures of cadmium and zinc to have influence on the histological responses in exposed specimens with the most histological characteristics identified being hyalinization of hepatocyte, increase vacuolation associated with lipids accumulation, congestion of blood vessels and cellular swelling. Sarkar *et al.* (2005) observed hyperplasia,
vacuolation, disintegrated blood vessels, disrupted hepatocyte, focal coagulative necrosis, disorganised hepatic canaliculi in the fish of *Labeo rohita* exposed to cypermethrin.

Koca *et al.* (2005) studied on the water quality and the distribution of some heavy metals in gills of *Lepomis gibbosus* from the Cine stream and observed a significant decrease in mean length of primary and secondary lamellae. Moreover, cellular proliferation developed with secondary lamellae fusion, ballooning degenerations or club deformation of secondary lamellae, distribution of necrotic, hyperplastic and clavate secondary lamellae.

Bravo *et al.* (2005) stated that kidney tubule alterations after exposure of (*Caquetaia kraussii* and *Colossomna macropomum*) to herbicide, triazine, included loss of plasmalemma and cell inter digitations, misshaped mitochondria, decrease in rough endoplasmic reticulum and free polysomes and the presence of autophagic vacuoles and primary lysosomes. These alterations at the cellular level may explain fish behaviour in terms of kidney tubule pathology and relative amounts and conditions of organelles within affected cells.

Epithelial hyperplasia, aneurism, curling and fusion of secondary lamellae were noticed in *Gambusia affinis*, after 30 days of exposure to deltamethrin, which was observed by Cengiz and Unlu, (2006). Wangsongsak *et al.* (2007) found out prominent tubular and glomerular damage in the kidney of common silver barb, *Puntius gonionotus* when exposed to the nominal concentration of 0.06 mg L\(^{-1}\) Cd for 60 days. Antonio Figueiredo-Fernandes *et al.* (2007) found that the main histopathological changes observed in gills exposed to 2.5 mg L\(^{-1}\) of waterborne copper for a period of 21 days were edema, lifting of lamellar epithelia and an intense vasodilatation of the lamellar vascular axis.

Abdel-Moneim *et al.* (2008) reported on the histopathological changes in catfish, *Clarias lazera* exposed to dyestuff and chemical waste water. Histological analysis of gill samples revealed a range of lesions including lamellar fusion due to hyperplasia and hypertrophy of epithelial cells, subepithelial cell oedema, collapsed pillar cell system and extensive lamellar aneurism. Liver pathologies included extensive necrosis of hepatocytes, cytoplasmic vacuolation, distended sinusoids with
massive congestion and infiltration of inflammatory cells through out the liver parenchyma.

Osman et al. (2009) studied on the two environmental pollutants namely copper sulfate and lead acetate that induced histopathological changes in the fish, Oreochromis niloticus. Babu velmurugan et al. (2010) observed on the histopathological effects of sublethal concentration of dichlorvos on the gill and liver of Cirrhinus mrigala.

Swarna kumari and Tilak, (2010) reported severe changes in the histology of gills, which led to the disturbance in basement membrane, degeneration of gill lamellae, cyst formation, swelling of base, increased lamellar space in the fish, Ctenopharyngodon Idella, when exposed to sublethal concentration of Nuvan 76% EC.

Jayaseelan et al. (2011) suggested that the gill damage along with thick mucous deposition in the gill filaments resulted due to the exposure of sublethal concentration of herbicide glyphosate, which lead to decreased efficiency for gas exchange and breakdown of vital function of Labeo rohita and finally leads to the death of animals.

Palanisamy et al. (2011) observed that the electroplating industrial effluent nickel induced hyperplasia, multiple telangiectases (aneurysms), desquamation of the epithelial cells, complete fusion of secondary gill lamellae and congestion of blood sinuses were the significant histological lesions in the gill of Mystus cavasius. Shanta Satyanarayan et al. (2012) studied on the histopathological changes due to some chlorinated hydrocarbon pesticides in the tissues of Cyprinus carpio. Liver showed abnormal fatty degeneration. Enlargement of liver was observed in few cases. Necrosis, congestion and fatty degeneration were also observed. Histopathological alterations induced by diazion on the gills and kidney of Rainbow trout (Oncorhynchus mykiss) was reported by Banaee et al. (2013).

2.8. MICROBIAL TREATMENT OF PETROCHEMICAL EFFLUENT

According to Song et al. (1990) petroleum hydrocarbon utilizing bacteria can tolerate oil - contaminated environments because they possess the capability to utilize oil as energy sources.
Few important bacteria such as *Pseudomonas* sp., *Alcaligenes* sp. and *Acinetobacter* sp. that are useful in bioremediation of halogenated aromatic compounds was studied by Chaudhary and Chapalamadugu, (1991). The microbiological bioremediation of oil polluted water is claimed to be an efficient, economic and versatile alternative to physico-chemical treatment, which was reported by Atlas, (1991).

Yatome *et al.* (1991) reported on the degradation of Crystal Violet by *Bacillus subtilis* IFO 13719. Besides Crystal Violet, two other triphenylmethane dyes (Prarosaniline and Victoria Blue) were degraded by growing cells of *Bacillus subtilis* IFO 13719. According to Atlas and Bartha, (1992) the microbial community carries out the majority of decomposition processes in the soil and are irreplaceable in the transformation and degradation of synthetic organic compounds and natural waste materials.

Ollika *et al.* (1993) observed that lignin peroxidase played a major role in the decolorization of azo, triphenyl methane, heterocyclic and polymeric dyes by *Phanerochaete Chrysosporium* and that manganese peroxidase was not required to start the degradation of these dyes of textile effluent. *Phanerochaete Chrysosporium* is a fungus, which also capable of degrading dioxins, polychlorinated biphenyls and other chloro-organics. Al-Hasan *et al.* (1994) observed on the utilization of hydrocarbons by cyanobacteria from microbial mats on oily coasts of the gulf.

According to Hinchee and Kitte, (1995) petroleum-based products are the major source of energy for industry and daily life. In the last few years, large numbers of ecosystems have changed by the significant influence of human activity and about five million tons of crude oil and refined oil enter the environment each year.

Desche Anes *et al.* (1996) observed that adding sodium dodecyl sulfate and *Pseudomonas aeruginosa* UG2 biosurfactants inhibits polycyclic aromatic hydrocarbon biodegradation in a weathered creosote-contaminated water.

Bioremediation involves the use of indigenous or introduced microorganisms to degrade environmental contaminants as reported by Margesin and Schindler, (1997). The population of microorganisms found in a polluted environment will degrade petroleum differently and at a different rate than microorganisms in a relatively clean environment, which was studied by Obire and Okudo, (1997).
Al-Hasan et al. (1998) studied the evidence for n-alkane consumption and oxidation by filamentous cyanobacteria from oil contaminated coasts of the Arabian-Gulf. Different types of organisms such as bacteria, actinomycetes, yeasts and fungi have been reported to decolorize and degrade different types of triphenyl dyes, which was studied by Azmi et al. (1998).

Bacterial species such as Bacillus sp., Pseudomonas sp., Acinetobacter sp., Achromobacter sp. and Streptomyces sp., are proved to be efficient fungal groups that evidenced phenol biodegradation, which was studied by Mordocco et al. (1999).

Basidiomycetous fungi, Ganoderma lucidum and Phanerochaete chrysosporium have been found very effective in bioremediation of the textile effluents, which was studied by Upadhyay, (2000). A number of bacteria’s such as Bacillus sp., Shewanella alga BrY-MT 10 and a few unidentified strains have been shown to reduce Cr6+ as reported by Shakoori et al. (2000). Assessment of toxicity of effluents from analysis of individual physico chemical parameters is often erroneous as most industrial effluents are complex mixtures of various components, they exert synergistic and antagonistic effect on organism. Use of organisms for monitoring water quality was suggested by Somnath, (2002).

Bioremediation is the most desirable approach for cleaning up many environmental pollutants. It is a pollution control technology that uses biological systems to catalyze the degradation or transformation of various toxic chemicals to less harmful forms was investigated by Ashoka et al. (2002). Ganguli et al. (2002) studied on the bioremediation of toxic chromium from electroplating effluents by chromate reducing Pseudomonas aeruginosa A2Chr in two bioreactors.

The ability to isolate high numbers of certain oil-degrading microorganisms from oil-polluted environment is commonly taken as evidence that these microorganisms are the active degraders of that environment, which was studied by Okerentugba and Ezeronye, (2003). Katsoyiannis and Zouboulis et al. (2004) reported on the heavy metal removal by oxidation processes, which were mediated by specific bacteria, namely the Leptothrix ochracea and Gallionella ferruginea, which belong to the general category of manganese and iron oxidizing bacteria.
Semra Ilhan et al. (2004) reported on the removal of chromium, lead and copper ions from industrial waste water by *Staphylococcus saprophyticus*. *Pseudomonas* sp., isolated from sugar industry effluent reduced the BOD, COD, toxicity of industrial effluents of pharmaceutical, sugar and dairy industries as reported by Anandapandian et al. (2004).

Christian et al. (2005) stated that use of white rot fungi is the most unique technology of bioremediation as their ability to degrade structurally diverse xenobiotic organo pollutants is more. According to Otokunefor and Obiaku, (2005) changes in microbial community structure may become permanent in areas exposed to chronic oil pollution and eventually result in complete alteration of structure of bacterial and fungal populations with serious consequences.

Watson and Cichra, (2006) observed that the bacteria and fungi are very critical to the breakdown of the toxic component of the effluent and the dissolved oxygen in water is required during the decaying of the organic matter, which may lead to depletion of oxygen in the water body and cause harmful substance to accumulate. Ojo, (2006) reported on the petroleum-hydrocarbon utilization by native bacterial population such as *Bacillus megaterium*, *Pseudomonas putida*, *Microccus luteus*, *Bacillus brevis*, *B. punilis* and *Enterobacter aerogenes* from a waste water canal, southwest Nigeria.

Crude petroleum oil and hydrocarbon degradation has been analyzed for several fungal and bacterial species, showing variable potentialities, by Nievas et al. (2007). Temperature and pH are the important physical variables and carbon, nitrogen, oxygen, phosphorus, sulfur, calcium, magnesium, and several metals are the micronutrients that also shows a significant impact on degradation behaviour as reported by Khazi et al. (2007). Chromium resistant bacteria such as *Bacillus* sp., and *Staphylococcus* sp., isolated from tannery effluents were found to be highly resistant to chromium at a concentration of 3.8 and 2.5 mg/l, respectively, which was studied by Sultan and Hasnain, (2007).

Bioremediation by using microbes is similar to waste water treatment as reported by Sathiya moorthi, (2008). Sathiya moorthi et al. (2008) reported that the fuel-eating bacteria known as *Pseudomonas* sp., have evolved a taste for hydrocarbons, the major component of fossil fuels and this study was able to degrade
the oils from the automobile effluent by *Pseudomonas* sp., with the best carrier based inoculum. Bako *et al.* (2008) studied on the bioremediation of refinery effluents by strains of *pseudomonas aerugenosa* and *penicillium janthinellum* in degradation of crude oil in Kaduna effluents.

Microorganism are able to degrade petroleum hydrocarbons and use them as source of carbon and energy. The specificity of the degradation process is related to the genetic potential of the particular microorganism to introduce molecular oxygen into hydrocarbon and to generate the intermediates that subsequently enter the general energy- yielding metabolic pathway of the cell, which was observed by Millioli *et al.* (2009). Debadatta Das, (2010) studied on the treatment of industrial effluents using mixed culture of two indigenous microorganisms, *Pseudomonas putida* (MTCC 1194) and *Escherichia coli* (NCIM 5051) for removal of phenol and Cr(VI) in a bio reactor.

*Pseudomonas fluorescens* can be used for bioremediation of textile effluent Direct Orange-102 as reported by Pandey *et al.* (2010). Obidi Olayide *et al.* (2010) reported on the bioremediation of crude petroleum polluted stagnant water with fermented cassava steep using *Penicillium* sp., *Aspergillus* sp., *Bacillus* sp., and *Streptococcus* sp. Ajao *et al.* (2011) studied on the bioremediation of textile industrial effluent using mixed culture of *Pseudomonas aeruginosa* and *Bacillus subtilis* immobilized on agar agar in a bioreactor.

High BOD and COD reduction in the treatment of textile effluent by *Pseudomonas* species was reported by Ashok Kumar *et al.* (2011) and Telke *et al.* (2012). Shruthi *et al.* (2012) observed that the isolated *Pseudomonas* sp., strain could effectively be used for the treatment of effluents from rubber processing industry.

Saranraj and Stella, (2012) recorded that the physico- chemical properties of the raw sugar mill effluent was found to be with a high BOD, COD, TSS and TDS. The immobilized bacterial consortium used for bioremediating the effluent showed a drastic reduction in the levels of COD, TSS, TDS, heavy metals and other physical properties after six months of treatment. Telke *et al.* (2012) studied on the significant reduction of BOD and COD of textile dyes and textile industry effluent by a novel bacterium, *Pseudomonas* sp. The reduction in pH, EC, TDS, BOD and COD in the treatment of sugar mill effluent by *Staphylococcus aureus* was reported by Buvaneswari *et al.* (2013).