

# **Methyl Parathion Induced Haematology Profile Alteration Of Climbing Perch, *Anabas testudineus* (Bloch.)**

## **ABSTRACT**

*Water pollution from agricultural wastes sources such as pesticides is now considered to be a major problem in worldwide. The present study includes the alterations induced by chronic (21 days) exposure of the fish Anabas testudineus to a sublethal concentration (0.047 ppm conc.) of methyl parathion on the haematology profile. The induced group shows significant alteration in the haematological parameters such as decreasing value in Hb, RBC, WBC while increasing value observed in DLC, Neutrophil, Monocytes and Eosinophil. The methyl parathion induced fishes may have various haematological diseases: Erythropoiesis, anaemia, Leucocytopaemia, Neutropaemia, Lymphopaemia, Eosinophilia and Erythrocytosis. Therefore, for the optimum growth performance of fish cultivation in contaminated water with pesticide, methyl parathion concentration should not be more than 0.047 ppm. The information will be major role on different levels of responses of organisms with respect to pollutant stress is a necessary pre-requisite for the proper management of pesticides application in agriculture.*

**Key words:** *Anabas testudineus*, DLC (Differential leucocytes count), PCV (packed cell volume), haematology profile, methyl parathion and pesticides.

## **INTRODUCTION :**

Water pollution from agricultural wastes sources such as pesticides is now considered to be a major problem in worldwide. Fish population are one among the non- targeted species to most of the pesticides because the aquatic environment is the ultimate recipient of virtually every form of human waste, including a number of chemical biocidal agents (Moyle and Leidy, 1992). “Pesticide contamination of aquatic system has increased in the last decades due to extensive use of them in agricultural, chemical and industrial processes which are becoming threats to living organisms” (Ajani and Awogbade, 2012). “The use of chemicals in agriculture and horticulture is viewed as a panacea to improve the productivity of crops and storage of food resources. As a result, the application of chemical pesticides to improve crop health and yield has increased worldwide. Pesticides are used to control pests in field for the crop production and vector control for the public health. It has been observed that not all the pesticides applied will reach the targeted

organisms. It has been estimated that only approximately 0.3 % of pesticides applied reach the target organisms, whereas 99.7 % contaminates the surrounding environment, such as air, soil, and water, through runoff, spray drift and leaching” (Jerald & Saradhamani, 2015).

“Methyl parathion is an organochlorine pesticide have high insecticidal property and low cost production make them worldwide popular. Methyl parathion has a half-life of 175 days in aqueous solution and 10 days to 2 months in soils. The rate of degradation increases with temperature and with exposure to sunlight. It is a non-systemic pesticide that kills pests by acting as a stomach poison and is used to control chewing and sucking insects in wide range of crops, including cereals, fruits, vines, vegetables, ornamental plants, cotton and other crops. It is generally applied as spray, mainly as an emulsifiable concentrate formulation. Like other organophosphate insecticides, methylparathion is a cholinesterase inhibitor. Its toxicity is largely due to the inactivation of the enzyme acetylcholinesterase (AChE) in insects and mammals” (Farm Chemicals Handbook, 2002). But due to its high persistent in nature and toxicity on non-target organisms especially fish in aquatic environment it is now banned. The world health organization classifies methyl parathion as a class ‘Ia’ extremely hazardous pesticide. It is highly toxic by inhalation and ingestion, and moderately toxic by dermal adsorption. Like other organophosphate. It has caused many health problems in human being, particularly in developing countries, since its introduction into the market in early 1950s.

The fish, *Anabas testudineus* (Bloch.), climbing perch is locally called ‘Kawai’, belong to family anabantidae of order perciformes. *Anabas* genus has two species, *Anabas testudineus* (Bloch, 1792) is bigger than *Anabas oligolepis*. “These fishes can stay for long time alive, out of water and sold in live condition usually, due to having the presence of suprabranchial accessory respiratory organs. Market demands for this fish are throughout the year in West Bengal and Bihar” (Mishra and Munshi 1958 and Roy, 1994). “This fish has unique feature sexually dimorphism, occurs in breeding season” (Dehadrai *et al.*, 1973). This is an important fish of paddy field culture in wetland region of this subcontinent. This is also subjected to severe effect of pesticides on fishes when huge application of pesticides in fields.

Therefore, in current paper an effort has been made to illustrate the methyl parathion induced haematological profile alterations of air breathing climbing perch, *Anabas testudineus*.

## **MATERIALS AND METHODS :**

The climbing perch, *Anabas testudineus*, live fish were procured from the local fish market, Darbhanga and brought to lab in open container. The healthy fish were measured  $10\pm 2$  cm and weight  $32\pm 2$  g, washed with 0.1%  $\text{KMnO}_4$  to remove dermal infection if any. Acclimatization for 15 days before experiment started. Fish was fed with commercial feed (28% crude protein) through the experiment period at the rate 3% of body weight. No aeration was done and follows the methods of APHA (1985).

The  $\text{LC}_{50}$  values of methyl parathion were determined for 24, 48, 72 and 96 hours following the static bioassay methods of APHA, AWWA & WPCF (1985). The resulted  $\text{LC}_{50}$  values for given period were 0.35 ppm, 0.25 ppm, 0.13 ppm and 0.095 ppm respectively. The sub-lethal concentration 0.045 ppm was determined (Hart *et al.* 1945). Ten fish were treated with concentration 0.047 ppm of methyl parathion and along with ten fish were taken as control for 21 days. On 21<sup>st</sup> day the fish were anaesthetized with 1:4000 MS 222 (tricane, methane, sulfonate, sandoz) for two minutes and blood samples were extracted at the site of caudal dorsal of the test fish. "The haematological parameters were estimated haemoglobin, RBC, WBC, Lymphocytes, neutrophil, monocytes, basophil, eosinophil and determination of PCV (packed cell volume) as follow the methods (Akela *et al.* 1996; Shrivastav, 1979).  $\text{MCV (fl)} = [\text{PCV (\%)} \times 10] / [\text{RBC count in millions/mm}^3]$ ,  $\text{MCH (pg)} = [\text{HB (g/dl)} \times 10] / [\text{RBC count in millions/mm}^3]$  and  $\text{MCHC (g/dl)} = [\text{HB (g/dl)} \times 100] / [\text{PCV (\%)}]$ ". [38]

## Results and Discussion:

The current study undertaken was the alteration in haematological profile of the fish, *Anabas testudineus* induced to (0.047 mg/l) sublethal concentration of methyl parathion for 21 days. The result in Table -1 showed a highly significant ( $P < 0.001$ ) decreases was observed in haemoglobin (Hb) of induced fish  $5.78\pm 0.10$  gm/dl than control  $8.89 \pm 0.05$  gm/dl. The present study revealed the decreases in haemoglobin (Hb) ( $5.78\pm 0.10$  gm/dl) of methyl parathion induced fish that was conformity with the works of Raizada and Gupta, (1982) in their study found a decrease of haemoglobin in the fungicide RH-216 induced fish, *Trichogaster fasciatus*. Similar alteration in haematological parameters in *Channa striata* was also studied by Sasikala *et al.* (2011). Arjun *et al.* (2009) have observed highly significant ( $P < 0.001$ ) as a decreased level of haemoglobin in the chromium exposed fish, *Clarias batrachus*. Similar haematological alterations results were observed by earlier workers with various toxicants treated fish; Hb decline was reported by Revathi *et al.* (2003), Shipra *et al.* (2005), Bruska *et al.* (2005), Anwar and Choudhary (2009). Roy and Nath, (2011) also reported similar haematological changes in case of Thiamethoxam treated *Oreochromis niloticus*.

The study revealed that RBC count in control fish was  $5.35 \pm 0.05 \times 10^6/\mu\text{l}$  while in treated fish  $4.11 \pm 0.05 \times 10^6/\mu\text{l}$ . The result showed decreasing a significant value ( $P < 0.001$ ) of RBC count in treated fish. Verma *et al.* (1982) also reported the alteration in RBCs count and haemoglobin concentration in *Mystus vittatus* induced by pesticides and infection of parasites. That physiological change was caused of deleterious effect of toxicants on the erythropoietic tissue of fish. *Heteropneustes fossilis* induced by pesticide, malathion showed decrease in RBC count from 6,400,000 to 3,460,000/cm in  $\text{LC}_{50}$  96 hr at 7.6 ppm reported by Mishra and Srivastava, (1983). Muthalagi (2006) has found similar nature of decrease RBC count under sewage treatment to the fish *C. mrigala*. The present study showed also conformity with Arjun *et al.* (2009) observed a decline in RBC under the treatment of chromium to the fish *C. batrachus*. Recently Pratibha and Kumar (2013) have observed the *H. fossilis* (Bloch) induced to mercury chloride showed similar decline nature of RBC.

The Table -1 showed in treated fish the values of Neutrophil, Monocytes and Eosinophil were increasing such as  $13.12 \pm 0.05$ ,  $7.0 \pm 0.05$  and  $3.2 \pm 0.05$  in compare to control fish value such as  $5.45 \pm 2.05$ ,  $4.0 \pm 0.05$ ,  $2.2 \pm 0.05$  respectively. The value of Neutrophil was highly significant ( $P < 0.001$ ), while Eosinophils showed significant value ( $P < 0.01$ ). Whereas Basophil has decreasing value  $1.4 \pm 0.02$  in treated fish than  $1.8 \pm 0.02$  control. That has been found non significant ( $P < 0.05$ ). The Table-1 revealed that in treated group the DLC (Differential leucocytes count) of Lymphocytes showed value was decreases  $32.0 \pm 0.02$  from control  $52.13 \pm 2.40$ . The Lymphocytes value showed significant ( $P < 0.01$ ). The present finding was conformity with Gomulka *et al.* (2014) has reported the induced European whitefish to propofol showed the significant reduction in the counts of lymphocytes, neutrophils and monocytes in haematology profile. The differential count (DC) of leukocytes was found a reliable haematological index to investigate the environmental contamination by various pollutants (Goger and Sawant, 1989). Sharma and Gupta (1982) found “considerable lymphocytosis; i.e., within 6 days, lymphocytes increased from 33 to 72% when fish exposed with  $\text{CCl}_4$  at concentration 0.03 and 0.06 ml/100 g body weight at intervals of 3 days. During present study the WBC decreases are close conformity with various workers, under the treatment of fertilizers, pesticides, alkaloids to fishes or mammals”. In fishes Muthalagi (2006) has been reported similar decrease of WBC under domestic sewage to the fish *C. mrigala*. Recently Arjun (2010) has explained “similar decrease of WBC under chromium exposure to *Clarias batrachus*. The present findings are conformity with various studies on mammals, such as rat, rabbit etc. under the exposure of metals, pesticides, alkaloids etc.. On the basis of above facts it is quite clear that WBC plays a very important role in the defense mechanism of body.

A decrease in WBC count in exposed fish is termed as leucopaemia". Another observation support the present work, Vasait and Patil (2005) found "decreasing lymphocyte count in *Nemacheilus botia* fish induced to organophosphorous insecticide". "The methyl parathion induced fish were showed that DLC- Neutrophil, Monocytes and Eosinophil increase while Lymphocytes, Basophil decreases in present study has close conformity with earlier works like under exposure of sewage" (Muthalagi, 2006), chromium exposed to fish (Arjun, 2010) and mercury chloride induced to the fishes (Pratibha and Kumar, 2011). Pratibha (2013) reported that induced *Heteropneustus fossilis* to mercury chloride showed haematological alteration.

The Table-1 showed that the PCV (Packed Cell Volume) value was decreases in treated fish group  $12.85 \pm 0.03$  while in control fish group  $34.91 \pm 0.06$ . The PCV value showed significant ( $P < 0.01$ ). The present findings are conformity with Revathi *et al.* (2003), Shipra *et al.* (2005), Anwar and Choudhary (2009). Pratibha and Kumar (2013) have explained exposure of mercury chloride to the fish *H. fossilis*. There were three ways as significant, highly significant or non-significant resulted by analysis of obtained haematological data. The methyl parathion induced fishes showed various physiological disorder in form of Erythropoiesis, anaemia, Leucocytopenia, Neutropenia, Lymphopenia, Eosinophilia and Erythrocytopenia.

Muthalagi (2006), Arjun (2010) and Pratibha (2013) found haematological changes in fishes under exposure of sewage, chromium as well as cadmium chloride that results conformity of present work. Fish induced to pesticide, methyl parathion showed increase in MCH and MCHC levels which may be due to increased haemolysis of RBCs and the reduction in the Hb concentration resulted by a decrease in cellular blood iron. The present work also conformity of work of Revathi *et al.* (2003), they observed similar in tannery effluent induced fish a decrease in PC, MCV, MCH and MCHC. The tannery effluent concentration influences the haematology profile. Similarly Arjun (2010) observed a significant decrease in PCV, MCV, MCH and MCHC of *Clarias batrachus* induced to chromium. Under the Cadmium chloride exposure to the fish, *H. fossilis* (Bloch) same decrease of PCV, MCV, MCH and MCHC found reported by Pratibha and Kumar (2013). In contrary found an increase in MCV, MCH and MCHC levels of *C. gariepinus* exposed by manganese (Olojo and Ladeji 2012). No significant effect on monocytes and basophils in *A. testudineus* under exposure of sub-lethal concentrations of methyl parathion used in present study. The reduction in basophils and lymphocytes and an increase in monocytes and neutrophils counts were found in present work. Whereas an increase in lymphocyte, eosinophils and monocytes with a decrease in neutrophils and

basophils concentration in *Garra gotyla gotyla* exposed to various concentrations of manganese was reported by Sharma and Langer (2014).

The haematological profile parameters like Hb, RBC, WBC were found decreases while in DLC, Neutrophil, Monocytes and Eosinophil values increases. Further Lymphocytes and PCV values decrease. The reduction of HB might be attributed to the blood coagulation. The reduction can be related to decrease RBC number which indicates haemolysis, haemorrhage and reduced erythropoiesis in fishes on exposure to pesticide.

**TABLE-1**

**Haematological profile changes in methyl parathion induced *Anabas testudineus***

Variable		Methyl parathion (96 hrs) exposure
Parameter	Control	20 mg/l
Blood Hb (gm/dl)	8.89 ±0.05	5.78±0.10 ***
TEC(RBC) (10 <sup>6</sup> cell/mm <sup>3</sup> )	5.35±0.05	4.11±0.05 ***
WBC (10 <sup>4</sup> cell/mm <sup>3</sup> )	4.92±0.05	2.25±0.05 ***
Neutrophil (10 <sup>4</sup> cell/mm <sup>3</sup> )	5.45±2.05	13.12±0.05 ***
Lymphocytes (10 <sup>4</sup> cell/mm <sup>3</sup> )	52.13±2.40	32.0±0.02 **
Monocytes (10 <sup>4</sup> cell/mm <sup>3</sup> )	4.0±0.05	7.0±0.05 *
Eosinophil (10 <sup>4</sup> cell/mm <sup>3</sup> )	2.2±0.05	3.2±0.05 **
Basophil (10 <sup>4</sup> cell/mm <sup>3</sup> )	1.8 ±0.02	1.4 ±0.02 *
PVC (% values)	34.91±0.06	12.85±0.03 **
MCV(fl/cell)	150.25±0.86	156.00±1.35
MCH(pg)	42.53±1.02	47.20±1.43
MCHC(g/dl)	24.05±1.05	29.38±1.05

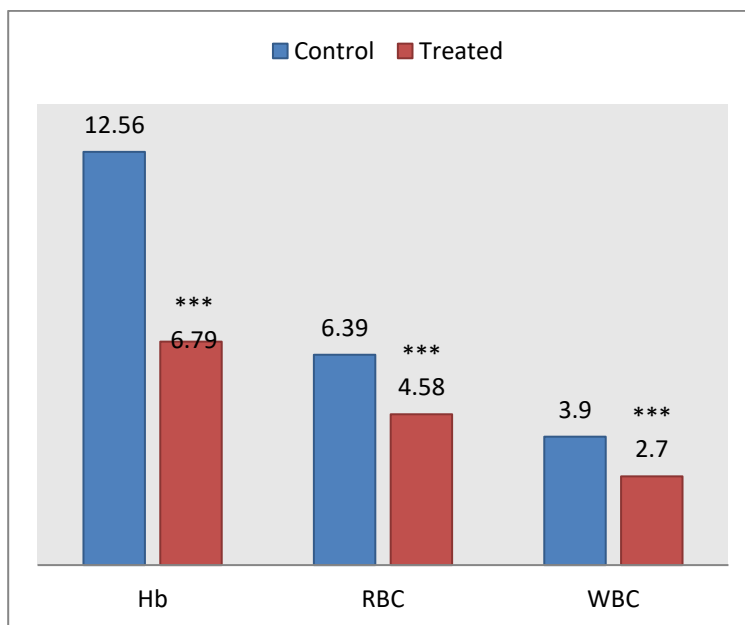
*Values are mean ± SE of 5 individual observations:-*

\*  $P < 0.5$  Non Significant,

\*\*  $P < 0.01$  Significant,

\*\*\*  $P < 0.001$  Highly Significant

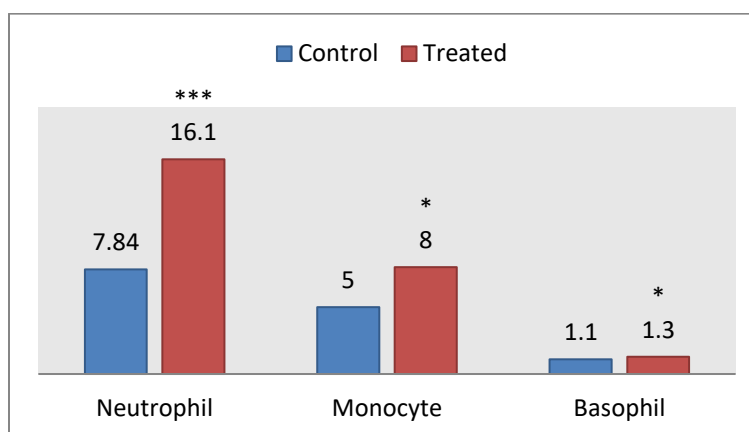
**Fig 1: The effect of Methyl parathion on Hb, RBC, WBC in *Anabas testudineus* (96 hrs) \*\*\*P < 0.001.**



PARAMETERS

**Figure-2**

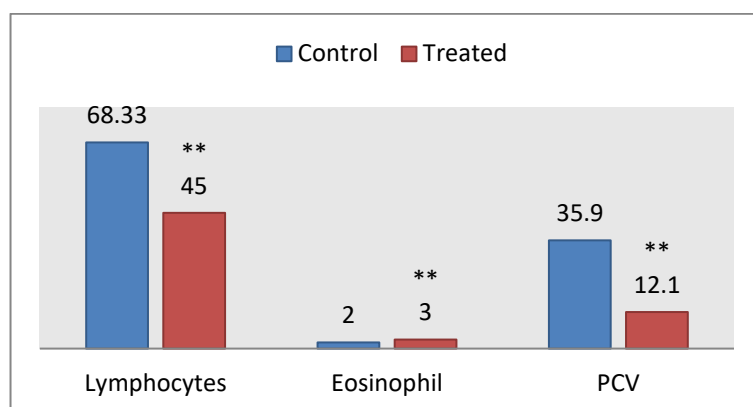
**the effect of Methyl parathion on Neutrophil, Monocytes, Basophil in *Anabas testudineus* (96 hrs) \*P<0.05, \*\*\* P<0.001.**



PARAMETERS

**Figure:-3**

**the effect of Methyl parathion on Lymphocytes, Eosinophil, PCV, in *Anabas testudineus* (96 hrs) \*\* P<0.01.**



## PARAMETERS

### CONCLUSION:

The present study has concluded that methyl parathion pesticide is a toxic for *Anabas testudineus* (average weight  $30.0 \pm 4.0$  g) culture at water contaminated with this at the concentration of  $< 0.047$  mg/l. The chronic toxicity has detected through haematological profile alteration. The induced group shows significant alteration in the haematological parameters such as decreasing value in Hb, RBC, WBC while increasing value observed in DLC, Neutrophil, Monocytes and Eosinophil. The information will be major role on different levels of responses of organisms with respect to pollutant stress is a necessary pre-requisite for the proper management of pesticides application in agriculture.

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## REFERENCES :

1. Abedi, Z., Khalesi, M.K. Eskandari S.K. 2013: Biochemical and Hematological Profiles of Common carp (*C. carpio*) under sublethal Effects of Trivalent chromium. Iran J. Toxicol.7:782-792.
2. Ajani, F. and A. A. Awogbade, 2012. Hematological Changes of the African Catfish *Clarias gariepinus* (Burchell, 1822) Juveniles Induced by Diuron, British Biotechnology Journal, 2(4), 247-256.
3. Anwar and Choudhary 2009: Effects of Quinine and Atropine to rat. J. of Natural conservatives Indian, 21(2), pp. 325-329.
4. Arjun Sah, Roy, D. N. Nutan 2009: Effect of Hb parameters on chromium to *C. batrachus*. J. of Environ & Ecoplaning 16 (1), 93-101.
5. Arjun S. 2010: Effects of chromium on haematological and histopathological parameters, *C. batrachus*. Ph. D. thesis, L.N.M.U., Darbhanga.
6. Barbieri *et al.* 2019: Lethal and sublethal effects of ammonia in *Deuterodon iguape* (Eigenmann 1907), potential species for Brazilian Aquaculture. Bol. Inst. Pesca 2019, 45(1): e440. DOI: 10.20950/1678-2305.2019.45.1.440.
7. Bruska-jastrzebska, E. and M. Protasowuki 2005. Effects of cadmium and nickel exposure on hematological parameters of common carp, *Cyprinus carpio*. Actalchthya et piscatorial, 35(1): 29-38.
8. Dehadari, P.V., Banerjee, S.R., Thakur, N.K. & Das, N.K., 1973. Sexual dimorphism in certain air breathing teleost. Inland Fish. Soc. India. 15, 71-78.
9. EIFAC (European Inland Fisheries Advisory Commission).1973: Water quality criteria for European freshwater fish report on ammonia and inland fisheries. Water Research, 7: 1011-1022.
10. Farm Chemicals Handbook, 2002: Methyl parathion. Global Guide to Crop Protection, In: R. Meister (ed.). Meister Publishing Company, Willoughby, OH. Vol. 88. P.C270.
11. Finney D.J. 1978: Statistical methods in biological assay. 3rd ed. London UK: Griffin Press; p. 508.
12. Goel, K. A., and Maya 1986: Haematological anomalies in *Clarius butrachus* under the stress of Rogor. Adv. Biosci. 5, 187-192.
13. Jerald Felix F., Saradhamani, N.,2015. Impact of the Herbicide Glyphosate Roundup (41%) On The Haematology of the Freshwater Fish, *Catla Catla* (Hamilton). (*IOSR-JESTFT*).Volume 9, Issue 4 Ver. III, PP 56-60
14. Klesius, P. H., C. A. Shoemaker, and J. J. Evans. 2000: Efficacy of a single and combined *Streptococcus iniae* isolate vaccine administered by intraperitoneal and intramuscular routes in tilapia (*Oreochromis niloticus*). Aquaculture 188:237–246.
15. Lata, S., Sriwastwa,V.M.S., Maurya, J.P. and Chaudhary,S.K.2008: Urea induced testicular changes in *Mystus vittatus*. J. Eco. Biol., 23:11- 17.
16. Mishra, A.B. & Munshi, J.S.D., 1958. On the accessory respiratory organs of *Anabas testudineus*. 15<sup>th</sup> International Congress of Zoology.
17. Mishra, J., and srivastava, A. K. 1983: Malathion-induced haematological and biochemical changes in the Indian catfish, *Heteropneustes fossilis*. Environ. Res. 30,393-398.
18. Moyle, P.B. and Leidy, R.A., 1992. Loss of biodiversity in aquatic ecosystem: Evidence from fish faunas. In: Conservation Biology: (Ed. By Fiedler, P.L. andJain, S.K.). New York: Champan and Hall. 129-169
19. Muthalgi, S. 2006: Effect of different concentration of sewage on the haematological parameters of *C. mirgila*. Indian J. Eniron.& Ecoplan 12(2), 409-412.

20. Palanivelu, V., Vijayavel, K., Ezhilarasi Balasubramanian, S. and Balasubramanian, M.P. 2005: Impact of fertilizer (urea) on oxygen consumption and feeding the freshwater fish *Oreochromis mossambicus*. *Environmental Toxicology and Pharmacology*, 19: 351–355.
21. Palanivelu, V. 1997: *Influence of Cartap andurea on the physiology of fresh water fish Oreochromis mossambicus*. University of Madras, Ph. D Thesis.
22. Paul, V.I. and Banerjee, T.K. 1996: Ammonium sulphate induced stress related alterations in the respiratory epithelium of the air breathing organ of the catfish (*Heteropneustes fossilis*). *Journal of Biosciences*, 21: 519-526.
23. Pathak P. & Anand A K., 2020: Biochemical changes of mercury chloride on blood metabolite level of freshwater fish *Heteropneustes fossilis*. *J. of Emer. Tech. & Inov. Res.*, Vol. 7(11).
24. Pratibha, K. 2013: Haematological & bio-chemical effects of mercuric chloride to *Heteropneustes fossilis*. Ph.D. thesis of L.N.M.U. Darbhanga.
25. Raizada, M. N., and Gupta, A. 1982: Toxic effect of Rh-2 16 (a systemic fungicide) from total erythrocyte counts (RBC) and haemoglobin (Hb) content of *Trichogaster fasciatus*. *Comp. Physiol. Ecol.* 7( 1), 29-30.
26. Rani, E.F, M. Elumalai, M.P. Balasubramanian 1997: The toxicity of mixtures of monocrotophos and methyl parathion to a freshwater fish *Oreochromis mossambicus*. *Biomedical Lett.*, **55** : 193-198.
27. Rewathi, K.M. Yogananda & K. Kaplarasi 2003: of tannary effluent on the bio-chemical and haematology of wistar albino rats. *Indian J. Environ & Ecoplan*, 7(3):629-632.
28. Roy, T., 1994. Fishes of WestBengal which need immediate conservation for saving from extinction. *Threatened Fishes of India*. Nacton Publication. 4, 37-43.
29. Sangeeta & Anand A K., Jha B.K., 2020: Toxicity Of Methyl parathion On Fish behaviour & Histopathology Of Air Breathing Fish *Clarias batrachus* (Linn.), *J. of Emer. Tech. & Inov. Res.*, Vol. 7(11).
30. Shipra, Shamra, R.P. Goyal, Geetanjali Chakravaraty & Anjali Sharma 2005: Orange red, a blend of permitted food colour induced haematological changes in swiss albino mice, 24(2) : 99-103.
31. Sprague, J.B., 1971: Measurement of pollution toxicity to fish. III. Sub – lethal effects and ‘safe’ concentration, *Water Res.* 5: 245- 266.
32. Todgham, A. E. Anderson, P.M. and Wright, P.A. 2001: Effects of exercise on nitrogen excretion, carbamoyl phosphate synthetase III activity and related urea cycle enzymes in muscle and liver tissues of juvenile rainbow trout (*Oncorhynchus mykiss*). *Comparative Biochemistry and Physiology*, 129: 527-539.
33. Ufodike, E.B.C. and Onusiriuka, B.C. 2008: Acute toxicity of inorganic fertilizers to African catfish, *Clarias gariepinus* (Teugals). *Aquaculture Research*, 21: 181186.
34. Vidal, M., Lopez, A., Santoalla, M.C. and Valles, V. 2000: Factor analysis for the study of water resources contamination due to the use of livestock slurries as fertilizer. *Agricultural Water Management*, 45: 1-15.
35. Vutukuru S.S., Basani K. 2013: Acute effects of mercuric chloride on glycogen and protein content of Zebra fish, *Danio rerio*. *J. Environ Biol.* 34:277–281.
36. Wicks, B.J., Joensen, R., Tang, Q. and Randall D.J. 2002: Swimming and ammonia toxicity in salmonids: the effect of sub lethal ammonia exposure on the swimming performance of coho salmon and the acute toxicity of ammonia in swimming and resting rainbow trout. *Aquatic Toxicology*, 59: 55–69.
37. Yanan, W., Yuan Z., Sun M., and Zhu W. 2015: Exploring the effects of different types of surfactants on zebrafish embryos and larvae. *Springer Nature. Sc. Rep.* article No. 10107.
38. Mala Kumari. Analysis of haematological manifestation of air breathing fish *Clarias batrachus* (Linn.) induced to deltamethrin. *International Journal of Fauna and Biological Studies* 2023; 10(6): 20-23

