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Studies of Bioaccumulation of Heavy Metals in Fresh Water Fishes of River Brahmaniat Rengalidam, Angul, Odisha

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Abstract: Heavy metal pollutionis a dangerous environmental delinquent because of their tenacity, poisonousness,bio-accumulation in additionto biomagnifications properties. Heavymetal pollution can occur from different anthropogenic and normal sources in the ecosystem. Disintegration of rocks that bears metalsanderuption of volcanoes are natural bases of heavy metals while the farming and manufacturingactions,burning of fossil fuels and gasoline, mining and waste furnaces are anthropogenic bases of heavy metallic element.Addition of these heavy metals into waterecosystem,changes the physical and chemical naturesof water which is harmful for the flora and fauna of water.During the ingestion of metal accumulated food materials,the heavy metals pass into the fish body mainly through surface of the body,lamellae anddigestive tract.When the metal accumulated food materials and metal contaminated water is used by aquatic organisms such as fishes,the heavy metals pass in their bodyover the gills, musclesand alimentary canal.Cd-Cadmium,Cr-Chromium,Ni-Nicke,As-Arseni,Cu-Copper,Hg-Mercury,Zn-Zinc,Sn-Strontium, Mn-Manganese,Fe-Iron are the utmostusual heavy metal contaminants that createacutenoxiousness infishes.The basic molecular process of metal poisonousness is the growth of oxidative stress. The immune system is weakened By the oxidative stress, immune system is weakened and causes the damage of tissues and organs which leads to defect in the growth and ability of reproduction.The fish is a goodbasis ofOmega-3 fattyacids, vitamins and proteins.Hence, it encourages the human to eat fish as amain source of food.Therefore,the fish tissues within which the heavy metallic elements have been gathered are transmitted into the body of human being and lead to lethal effects to create severalillnesses.Hence,this is essential to discourse the toxic effects on the health of the fish to increase various diseases and the sources of heavy metals to imposethe rule and legislation about their safety in the environment of water in addition to protect life of human being.This study was conducted during the post monsoon period to determine the pollution water by heavy metals and bioaccumulation into fresh water fishes of Mystusseenghala,Cirrhinusreba,Labeocalbasu,Puntius ticto and Mystus vittatus from the RengaliDam in the river Brahmani of Angul district of the state Odisha.The tissues of gill and muscle of fishes were studied for the existence of heavy metals like Mn,Fe, Zn and Sn etc.usingX-Ray Fluorescence Spectroscopy studies.

Key words: River Brahmani, Heavy metals, fresh water fishes and bioaccumulation, SDG 13

1. Introduction

The River Brahmani is a prime seasonal river of Odisha. It has been made by the convergenceof Sankh and South Koel Rivers nearRourkela, one of the industrial towns of Odisha.This river has its origin from Chhattisgarh to Jharkhand which is border very near to Netarahatplatue.This river streams through the district of Sundargarh,Deogarh,Angul,Dhenkanal,Cuttack,Jajpur and Kendrapara district of Odisha.It joins to the Bay of Bengal at Dhamra.It coordinates 22° 14′ 45′′ N and 84° 47′ 02′′ E.Latitude-20°28′-23°38′N and Longitude-83°55′ to 87°3′E.The length of this river is about799 km.The basin of the river is rich in a variety of mineral contents such as Iron ore,Copper,Buxite etc.The industrial development potential of this river basin is very high due to this rich mineral resources and power potential.Rourkela is an important industrial centre located in this river basin.Iron and steel, fertilizers,DDT and insecticide factories are located here.Rengali dam is constructed across the Bramhani River in the Rengali village of Angul district of the state Odisha.The longitude of Rengali dam is85°01′57′′E and latitude is 21°16′36′′N. The samples of various kinds offish species were fetched from the area ofRengali dam from the fisherman inlive condition.

Now-a-days,the environmental pollution has been a major challenge for human community(Ali et al.,2019).The ecologicalcontamination has been increased from the last few decades due to the rapid growth ofindustries, increase demand of energy and inattentive destruction of the natural resources Gautam et al.,(2016).From the natural and anthropogenic sources,different inorganic and organic toxic materials are being released constantly to the terrestrial and aquatic environment.For their poisonous properties andhaving the capability of bio-accumulation in the nutrimentchain,the heavy metals are playing a mainpart in the pollution of the environment(Briffa et al., 2020). The work of Gheorghe et al., 2017, states that the heavy metals are generallyreleased from the agricultural and domestic wastesmatters,burningof fossil fuels, industrial waste products, waste water treatment and mining activities.Pollution of metals has been a health concern all over the world for a long period time(Makedonski et al., 2017).In anormalenvironment, the heavy metals are tenacious and pass into body of living organisms and it can be accumulated within.The heavy metallic elements contaminating the land are simplyabsorbed by the florae and leads to severaltypes of difficulties such as inhibition of growth,chlorosis,defect in photosynthesis and water balance senescence and finally death(Stangeeva et al.,1995).The pollution of soil by heavy metals also affect the balance of microbiology and the fertility of soil is reduced(Barbieri,2016).In the aquatic ecosystem ,the heavy metals can be simplymelted and laterpass in the body of the organisms living in water(Authman et al.,2015).Then these metalspass into body of theorganisms of higher trophic level through the food chain. According to thestudy of Malik et al.,(2014) states that the normal physiological activities are damaged by cause of the bio-

accumulation of poisonous heavy metals in various tissues which may lead to injury to the health of different animals. The capacity of reproduction and the rate of survivability of the organisms are drastically affected due to toxicity of heavy metals.Ngo et al.,(2011) has studied that many of these heavy metalshave high mutagenic properties, carcinogenic and teratogenic properties relying ondoses,period of exposure and the type ofspecies.Metal pollution possesses a consequential warning to the biological and well-being of human(Tao et al.,2012;Wang et al.,2013). The pollution of heavy metals is a most importantproblem. Dueto the poisonousnessand bioaccumulation properties of heavy metals,they caneffortlesslypass in the body ofman via nutriment chain and also affects other organisms(Tahir et al., 2017).Has-Schon et al.,(2006); Saleemi et al.,(2019) reveals that the toxicity can simply be determined in view ofseveralaspects as to quantity the level of feeding and contamination of water,bio-accumulation andharmfulness of heavy metals accompanied by biomagnifications in alive organisms.The study of Bosch et al.,(2016) found that due tonoxiousness and non-biodegradability properties of the heavy metals,they can be bio-concentrated and biomagnified overnutriment chain even in a very littleamount in the ecosystem.The direct exposure of the aquatic biota todissolved heavy metals in water or existing as deposit in aquaticbodies(Youssef andTayel,2004).The metals like Co,Ni,Cu,Mn,Fe,and Znare essential in little amount for well-functioning of enzymes,formation of hemoglobin and synthesis of vitamins in human body but the extreme quantity of this elements accompanied by heavy metals such as Pb,Cr,Hg and As leads tonumerousfunctionalillnesses like damage of liver, disorders related to cardiovascular system and renal failure in human being(Qin et al.,2015 andDong et al.,2016).In the aquatic ecosystem,fishes are the top consumers and mostly affected organism(Luo et al.,2014).Sometimes, the nervous system of the fish is damaged due to the harmfulness of heavy metals and that disturbs theinteraction of fish with its ecosystem(Baatrup,1991).Human being isomnivorous andunprotected to lethal heavy metalsfordiversestuffs of nutrientslike vegetables, cereals and fish etc.Hence,concentration of heavy metals inside the body offlora and faunas of water can be biomagnified and perseveredbyfood chain andtransmittedinto the body of human being(Has-Schon et al.,2006).According to the observation of Kalantzi et al.,(2016),Incase oftissues of fish, the accumulation of metalsmainlyrest on thepollution load of surrounding aquatic medium ,cycle of growth of fish, degree of prey , bio-availability,trophic levelin the aquatic food chain and age.Thefish possess the high trophiclevel, hence they are always considered as bioindicators for the pollution of metals. For these reasons, numbers of researches have been guided by the researchers to resolve the level of heavy metals in the tissues of fish and for the valuation of their risk of consumption for human(Alamdar et al.,2017;Durmaz et al.,2017;Monferran et al.,2016; Noel et al.,2013;Sarkar et al.,2016;Rahman et al.,2012;Taweel et al.,2013). TheconclusionsofRahman et al.,(2012) revealsthat toxicity of heavy metals has become a threat for fish consumers all over the world.For the

improvement of thehealth,nutrition and wellbeing of human being,the fish products epitomize a vitalconstituent of the universal food carrier.Fish food is considered as a goodfoundation of proteins,minerals,vitamins, some trace elements andomega-3 fatty acids(F.A.O.,2014). According to the report of Thilsted(2013) and F.A.O.(2014),InBangladesh, fish is a uniquesource of animal proteinparticularly for the poor rural people who suffer from malnutritions.

The current study purposes to discoursebioaccumulation and the toxic resultof various heavy metals likeMn,Zn,Fe and Sn,on the health of fish as a resultnecessarymeasuresmay be taken to lesseneffects of such heavy metalic elements in the environment.

2. Materials and Methods

Study site

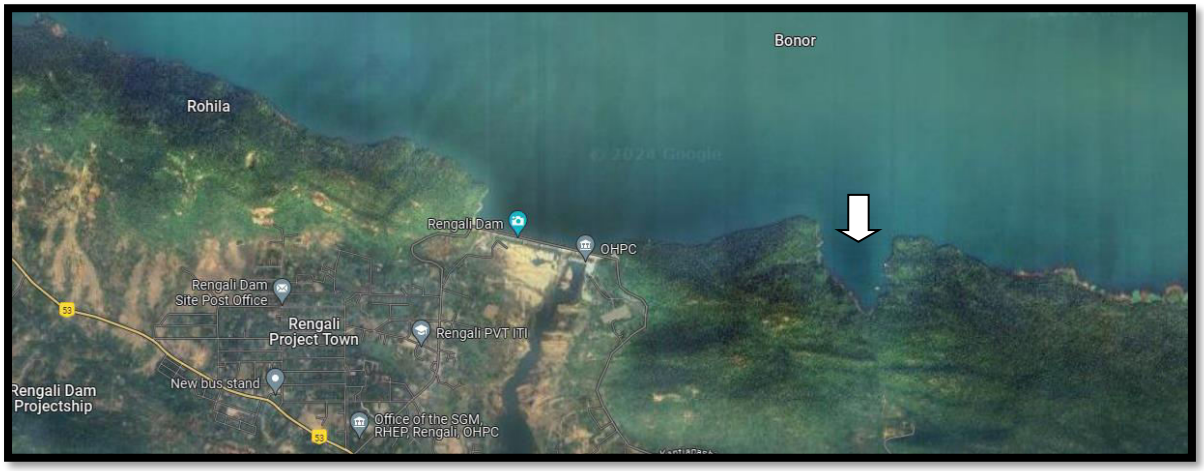

Figure-1 Google map showing study site and collection of fishes indicated by arrow mark

The fresh water fish samples such as Mystusseenghala(Kontia), Cirrhinusreba(Pohola), Labeocalbasu(Black rohu),Puntius ticto and Mystus vittatus (Tengara) were collectedfrom different places across 500 meters radius of River Brahmani at Rengali Dam site of Angul district of the state Odisha.Fish samples were collected in post monsoon periods.The collected samples were kept in ice container at -4°C to 0 °C and transferred to thelaboratory for study.Polythene bottles having screw caps of one-liter capacity were cleaned and soaked with 5% nitric acid.Then rinsed by disilled water before collection of water sample for study. About 2 feet depth from the water surface, Samples of water were collected in these water bottles from the dam sites for study.

Methodology:

Immediate after collection, the acidification of the collected water samples was done by adding 5 ml of nitric acid in order to reduce the heavy metal adsorption onto the

walls of the bottles (APHA;2004). For the detection of heavy metals,the analysis samplesof waterwas done by Atomic Absorption Spectrometer.Furthermore,byfollowing the method of MohiuddinShaik (2014),the fish samples were collected and analyzed.The fish samples were cleaned properly,weighed and their length and weight were measured and recorded.Then, they were dissected to remove the gill and muscle tissues.The dissected tissues of gills and muscles were cleaned properly with distilled water to remove undesirable materials and weighed.These tissues were kept in Petri dishes and Petri dishes were kept in oven for drying at 120°C.Then after drying,the dried tissue was homogenized with the help of mortar and pestle to make powder.Then, 1.0 gm of powdered tissue was transferred to X-ray Fluorescence spectroscopy testing Cup and the content of metals were measuredby X-Ray Fluorescence Spectroscopy.

Statistical analysis:

Bymeans ofMicrosoft Excel software, the data was statistically analyzed.

Table no-01: length and weight of five fish species.

SL.NO.	NAME OF FISH	LENGTH OF THE FISH(cm)	WEIGHT OF FISH(gm)
01	Mystusseenghala	24.4±0.239	125.6± 1.187
02	Cirrhinusreba	17.4±0.264	67.2±2.344
03	Labeocalbasu	20.5±0.275	131.9 ± 3.0
04	Puntius ticto	7.4±0.249	13.6±1.793
05	Mystus vittatus	10.0 ± 0.872	26.2±2.174

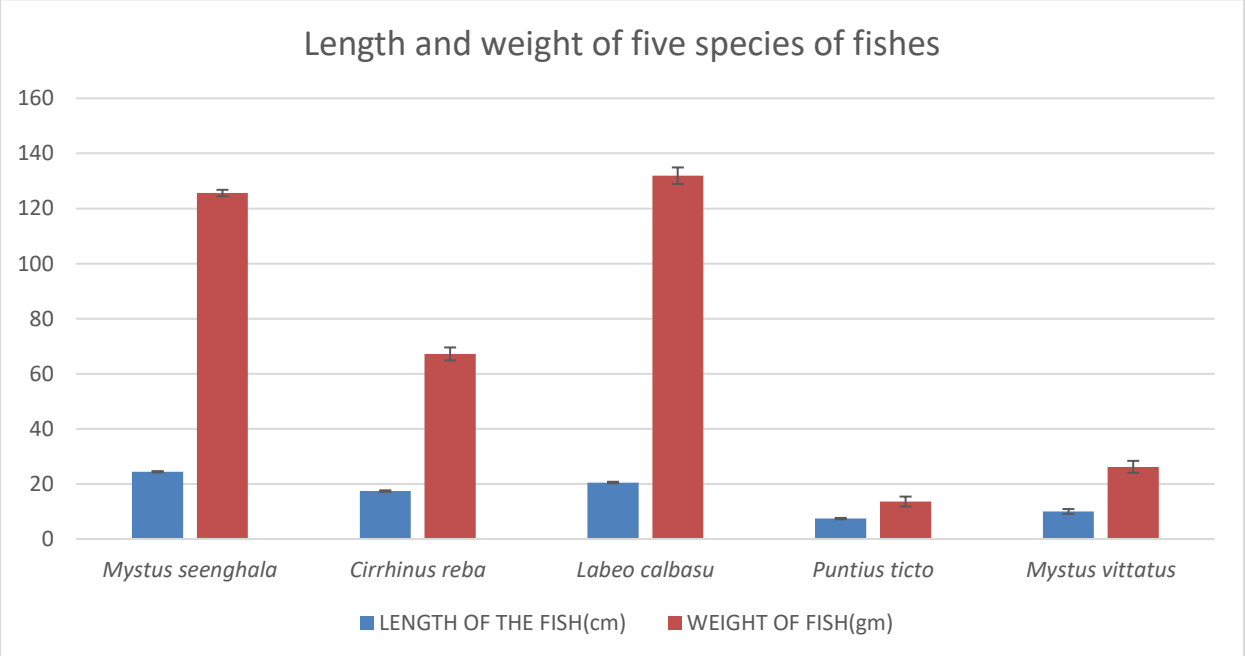

Figure-2. Graph showing length and weight relationship of five fish species.

Table No-02:Concentration of the analyzed heavy metals (Mean ±Standard Deviation) in the tissues of gills and muscles of the fishes

Name of fish	Tissue	Mn (mg)Mean± SD	Fe(mg)Mean ±SD	Zn(mg)Mean ±SD	Sn(mg)Mean ±SD
Mystusseengha la	Gill	0.334±0.020	45.333±0.030	6.845±0.021	2.366±0.024
	Muscle	0.233±0.13	35.342±0.022	5.729±0.028	1.860±0.014
Cirrinusreba	Gill	4.132±0.022	24.229±0.029	12.857±0.026	3.042±0.030
	Muscle	1.358±0.027	22.719±0,025	3.679±0.039	2.638±0.018
Labeocalbasu	Gill	3.047±0.021	26.044±0.021	15.738±0.018	3.049±0.026
	Muscle	2.757±0.014	19.84±0.025	14.230±0.016	6.929±0.033
Puntius ticto	Gill	2.962±0.015	13.935±0.019	5.876±0.016	3.147±0.019
	Muscle	2.741±0.016	13.474±0.011	5.475±0.010	2.629±0.020
Mystusvittatus	Gills	1.944±0.15	22.969±0.012	5.430±0.020	13.319±0.021
	Muscle	1.724±0.021	22.585±0.021	4.485±0.022	12.909±0.023

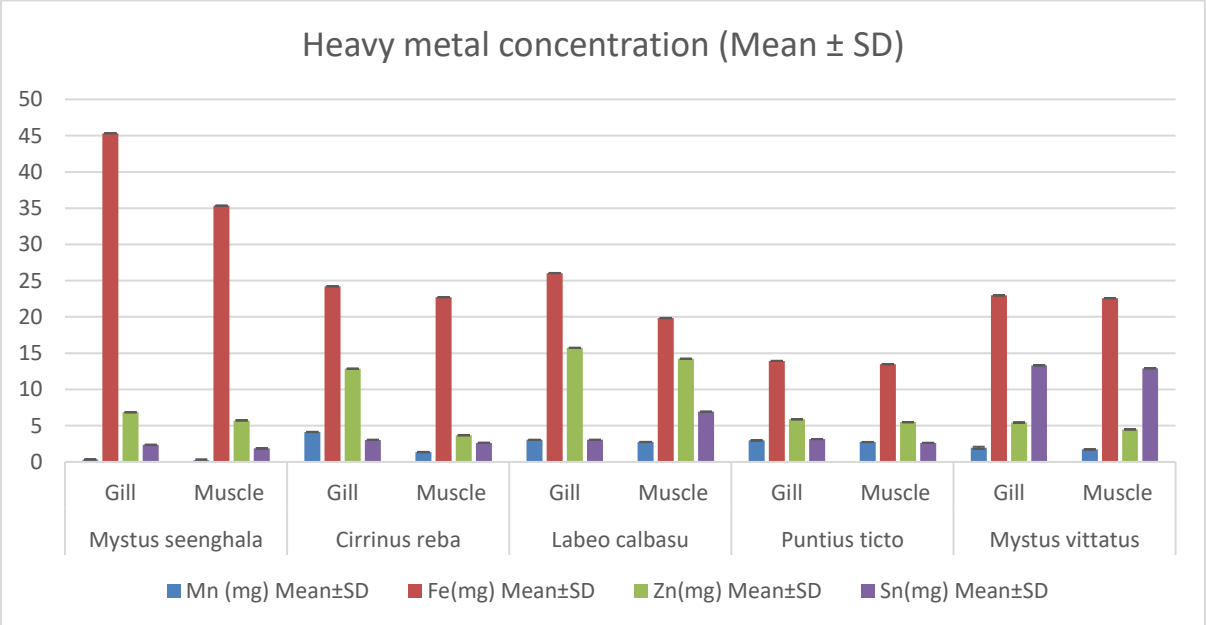

Figure-3. Graph showing concentrationofheavy metals in gills and muscles tissues of five fish species

Table-3 Concentration of metals (Mean ± SD) of the analyzed heavy metals in water sample

Site	Water Sample	Mn (mg)Mean±SD	Fe(mg)Mean± SD	Zn(mg)Mean± SD	Sn(mg)Mean± SD
Site - 1	Water Sample	4.848±0.019	46.442±0.019	16.540±0.025	14.266±0.021
Site – 2	Water Sample	4.260±0.018	46.156±0.020	15.964±0.017	13.615±0.030
WHO Standards	Drinking water	11	50	5	0.002

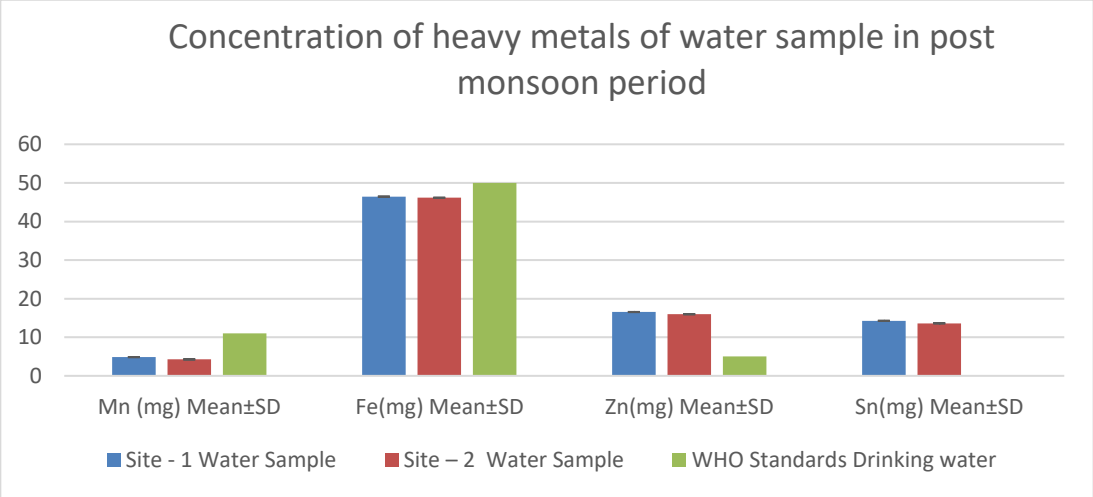

Figure-4. Heavy metal concentrations (Mean ± SD) in the samples water compared with WHO Standards

3. Result and Discussion:

Bioaccumulation of metals is defined as a process of increase of the concentration of metals in the body of the organism derived from the food either by ingestion or absorption and from the surrounding medium where it lives (Forstner,1981).The water becomes toxic is caused by the presence of heavy metals in aquatic environment. Depending on various factors, the species of different fishes take the heavy metals in different forms at various rates. According to the study of Ashraf et al.,(2019), the degree of poisonousnessrelies on the kind of metals, its biotic function and the sort of organism which are being exposed to it. The concentration of metals can be regulated up to a certain limit in the body of fish and after that the bioaccumulation takes place (Heath,1991). According to the study of Ashrafetal.,(2019), the degree

ofpoisonousnessrest on the kind of metals, its bioticfunction and the kind of organism which are being exposed to it. Further,according to the study of Oronsaye,(1987);Gerhardt,(1992)and Adeyeye, et al.,(1996),in the body of an organism,the concentration of metals varies in different organs and it is the result of an equilibrium between the concentrationof metals in the ecosystem of the organism and the rate of ingestion and excretion by the organism.The heavy metal is either metabolized, excreted, stored or bioaccumulated inside the body of fish (Alewu and Nosiri, 2011). In case of fish, the bioaccumulation takes place after regulation limit of metal concentration exceeds (Heath,1991). Fishes live in water and feed from the aquatic environment, hence they are highly vulnerable to heavy metals and pesticides. Hence,aquatic habitat of fishes diminishes, food chain is disrupted and diminishes the food sources for the lethal effects of heavy metals (Haseem and Mohammed,2019;Naeem et al.,2021).The findings of Naeem et al., (2021) has shown that in case of fishes,accumulation of heavy metals rest on theduration of exposure and concentration of heavy metals, PH, hardness and nature of water and content of dissolved oxygen.

Heavy metal Concentration in fish tissues

Samples of fish and water were collected from Brahmani River at Rengali dam site of Angul distric of state Odisha. The results of concentrations of heavy metal in the water of Bramhani River at the site of Rengali dam are shown in Table-1 and Concentration of heavy metals in the tissues of different species of fishes are shown in Table-3.Themean concentrations and Standard Deviations of essential elements (Mn,Fe, Zn) and non-essential element-Sn in the tissues of gills and muscles of five species of fish such as Mystusseenghala,Cirrhinusreba,Labeocalbasu,Puntiusticto and Mystus vittatuswere summarized in Table-3.A statement of comparison of the concentration ofheavy metalsin different tissues of fishes are shown in figure-1 and the concentrationof heavy metalsin water samples are shown in Figure-3.

Mn- Manganese:

Though Manganese has a considerable biological significance but it is a low toxic element. The findings of Ahmed et al.,(2016) and Moreno et al.,(2009) states that neurological disorders and psychological problems may arise due to the high ingestion of manganese. In the currentinvestigation, the rate of bioaccumulation of Mn is higher in gill tissues and lower in muscle tissues of Mystusseenghala, Cirrhinusreba ,Labeocalbasu,Puntius ticto and Mystusvittatus.The Variations in significant level ($P<0.05$) of concentrations of Mn were observedin the tissues of gill and muscle of all the five species of fishes. These were examined by one sample t-Test and compared with the WHO Standard according to Geneva,(2011)(Table-3). The level of accumulation of manganese is less than the standards of WHO according to guidelines of Geneva, (2011).

Malfunctioning of the body metabolism occurs in human due to consumption of excess.

Fe-Iron:

The body needs iron as an important mineral for the proper growth and development. It helps in the transfer of oxygen and body metabolism as a component of bone protein and enzymes. Iron is not harmful to animals. It is also not harmful to aquatic animals at normal level. But, it is insoluble in the water. All the aquatic living organisms including fish unable to process all molecules of iron they absorb from aquatic environment and their food. Iron is predominantly present in the mining and industrial wastes and these are frequently released into aquatic environment (Andromeda, 2021). Comparatively, it is considered that Fe are discharged into the water body and ultimately cause harm. Bury and Grossel, (2003) has reported that the excess amount of dissolved iron in water can lead to form iron flakes on the gills of fish and leads to obstruction and disorders in the respiratory tract. Sometimes, the tissues of gills are lost to necrosis in severe cases. It has been shown in the finding and reports of Anderson et al., (2014) that there is neurodegeneration due to the deposition of Fe (iron) in the regularly inflamed central neural system. The oxidative stress and radicals of oxygen are formed due to the excess Fe in human body. The studies of Chen et al., (2012); KosLowski et al, (2003); Andersonet al., (2014); and Romano et al., (2021) has shown that some inflammatory problems like illnesses in the central nervous system, degradation of neuron, Alzhemer's disease and Parkinson's disease are related to the excess quantity of Fe in the body of human. In the present study, the rate of bioaccumulation of Fe is maximum in Mystusseenghala and less in Puntius ticto. Accumulationin the tissues of gill is more than the tissues of muscles in all the species. In all the above cases, the amount of accumulation does not surpassthe permissible edge of WHO standards according to the guidelines of Geneva, (2011). The substantialdifferences ($P<0.05$) of the concentrations of Fe(iron) were observed in gill and muscle tissues of all the five species of fishes which were examined by one sample t-Test and compared with the WHO Standard according to Geneva, (2011).

Zn-Zinc:

Zn is a naturally occurring element in environment. Zn is one of the essential trace and micronutrients of the living organisms. It has some biological role as the transcription factor in human and other animals. The study of Tabari et al.,(2010) states that Zn is involved in the synthesis of Nuleic acid hence it is found in almost every cell of the organism. Khaled, (2009) states that the paint containing Zinc, Zinc used in plumbing, the galvanized iron work are the common sources of Zn. The gills of fish are main target of waterborne levels of zinc occurs due to Zn wastes and that can have direct toxicity of fishes. The gills of fish are main target of waterborneZn toxicity,which leads to low calcium level in the blood and subsequent death(Tabari et

al.,2010). The Zinc accumulation by the gills of fish producesantagonistic effects on fish by producingproblems in the function of the body such as neurotransmission, cell signaling (Afshan et al.,2014). It can change the behavior of the fish, the parameters of the hematology, hatchability, balance and the ability of swimming. The impact of Zn on common carp (Cyprinuscarpio) was studied by Cicik(2003) and found that the tissues of gills accumulate the maximum amount of Zn. The work of Lazi abu, on Cyprinus carpio and grass carp was undertaken by Huseen and Mohmed, (2019) and they reported that due to the mucus secretion of gills, the concentration of Zn is high in gills and alterations in the structure of tissue of gills are caused by the contamination, furthermore, the kidney, muscles and skeletal muscles are the other target organs of Zn toxicity. Al-Taee et al.,(2021) reports that higher dose and acquaintance of Zn to human may leads todeficiency of coordination of muscle. In the currentwork, the paternof gathering of Znin tissues of fish were higher in the case of gills than the muscle tissue. In the case of Mystusseenghala, Cirrhinusreba,Labeocalbasu, Puntius ticto and Mystusvittatus, the highest amount of accumulation of Zn was found in the gills and lowermost accumulation were found in the muscles. But in case of C. reba,the accumulation of Zn in the tissue of gills is about 3times more than the accumulation in the tissue of muscle.Further,the accumulation of Zn in both the tissues of L. calbasuis around three times more than the WHO standard according to the guide lines of Geneva(2011).The variation in significant levels($P<0.05$) of Zn concentration were observed in muscle and gill tissues of all the fish species studied here which were examined by one samplet-Test and compared with the WHO standard according to the guidelines of Geneva(2011).The presence of Zn content is higher than the normal quantity in both the collected water samples hence the bioaccumulation is much more in case of the all the five fishes except the Muscles of Cirrhinusreba.

Sn-Tin:

Tin (Sn) is a metal. It can exist by itself as a pure compound or as part of inorganic compound or organic compounds. Inorganic tin compounds are formed when tin combines with other element such as chloride, fluoride, sulfur or oxygen. Organic tin compounds are formed when binds to carbon. Tin is used to make plastic, pesticides, paints, wood preservatives and rodent repellants. In the aquatic environment, some of the applications of the components of organotinshave been discontinued due to their high toxicity (ATSDK,2005;Jancso,2010). Tinis not an essential element for human (ATSDR,2005). The foods like sea food, food products in tin-lined cans contaminated by tin compounds and use of house hold products are the major sources of human vulnerability to tin. In the present study, the bioaccumulation of tin (Sn)is maximum in tissue of gills ofMystusseenghala,Cirrhinusreba,Puntius tictoand Mystus vittatus than the muscle tissues. But in case of Labeocalbasu, the pattern of accumulation of Sn is more in muscletissue than the gill tissue.The substantial variations ($P<0.05$)in

the concentrations of Sn were observed in gill and muscle tissues of all the five species of fishes which were examined by one sample t-Test and compared with the WHO Standard according to Geneva(2011) (Table-3). The presence of Tin (Sn) in the water samples and bioaccumulation are much more than the WHO standard according to the guide line of Geneva (2011).

4. Conclusion:

The present study has described the possible risk of heavy metals for the native people due to eatingof fish from Brahmani River from site of Rengali dam of Angul district of Odisha. It was found that the order of concentration of heavy metals followed are Fe>Zn>Sn>Mn.Due to the process of bioaccumulation,the amount of some heavy metals like Mn and Fe in the species of fish were detectedlesser than the acceptablerestrictionsfixed by WHO.The contamination of Zn and Sn in the species of fish were found higher than the permissible limits set by WHO.The assessedeverydayconsumption of Zn and Sn(mg/day/person) exceeds the suggestedday-to-daynutritional allowances.The contamination of Znindicates; the consumers may experience the lackof muscular coordination. The Zn contamination may adversely affect the industry of fisheries.Again,this indicates that the consumption of above studied fish species from Brahmani River may cause above mentioned problem for life time eating.The sources of these metals are the anthropogenic activities and the geological origin.Therefore,the implementation of regulatory steps for the control of pollution and discharge of heavy metals into the ecosystemshould be followed strictly. A special awareness should be given towards the probable risksof health because of taking fish with a higher concentration of metals.

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Conflict of interest: None

5. References

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