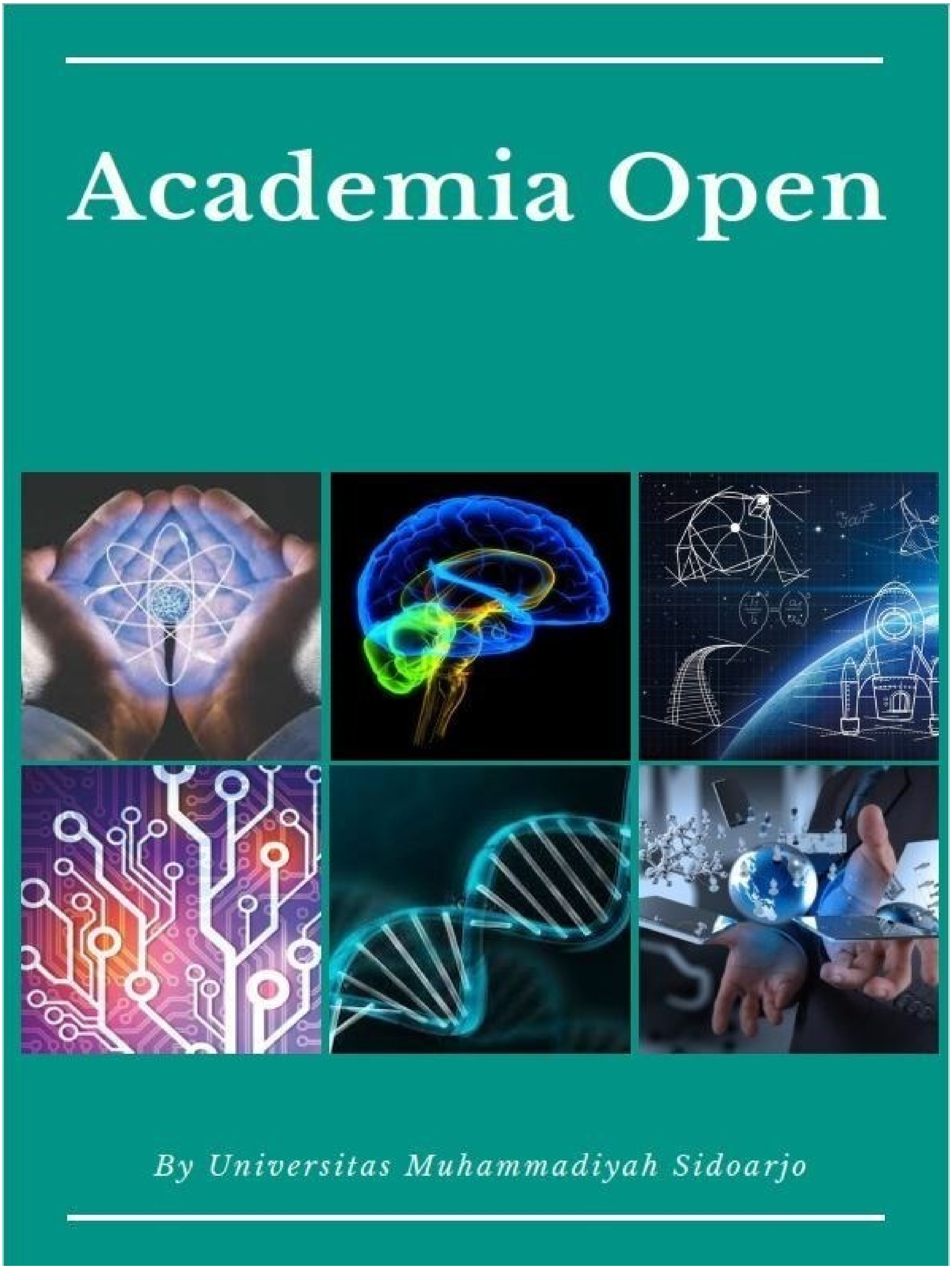
Academia Open

Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.13049



ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open

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DOI: 10.21070/acopen.10.2025.13049

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Vol. 10 No. 2 (2025): December
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ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

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Academia Open
Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.13049

Assessment of Trace Elements in Water, Sediments, and Fish Tissues from the Al-Gharraf River

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Abstract

General Background: Effective **General Background:** Trace elements are persistent environmental contaminants that accumulate in aquatic systems and pose ecological and health risks. **Specific Background:** The Al-Gharraf River in southern Iraq receives inputs from agricultural, industrial, and domestic activities, increasing concern about metal enrichment in water, sediments, and fish. **Knowledge Gap:** Despite regional studies, data on the simultaneous distribution and bioaccumulation of cadmium and zinc in multiple environmental compartments of this river remain limited. **Aims:** This study assessed concentrations of cadmium and zinc in water, sediments, and fish tissues across three months to determine contamination levels and ecological implications. **Results:** Findings showed pronounced elevation of both metals in December compared with November and January, with the highest accumulation recorded in sediments and in fish gills and liver, while muscles exhibited comparatively lower concentrations. The consistent month-to-month variation demonstrated active metal inputs and dynamic environmental interactions that facilitate bioaccumulation. **Novelty:** This study provides integrated, compartment-based evidence of trace-metal distribution in a key river system using synchronized sampling of water, sediment, and multiple fish tissues. **Implications:** The results underscore the urgent need for strengthened monitoring and management strategies to mitigate metal pollution and safeguard ecosystem integrity and public health.

Highlight :

- Shows increased cadmium and zinc levels in December across all sample types.
- Fish organs, especially gills and liver, display clear bioaccumulation patterns.
- The findings underline the need for stricter environmental monitoring.

Keywords : Trace Metals, Al-Gharraf River, Water, Sediments, Fish Tissues

Published date: 2025-12-11

Academia Open
Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.13049

Introduction

In the lat.est yea.rs the.re has been ris.ing inte.rest regar.ding met.al contami.nations in the aqu.atic enviro.nments, seemi.ngly due to the.ir toxi.city and remar.kable persis.tence wit.hin aquatic syst.ems. The aqua.tic enviro.nment consists mai.nly of thr.ee sour.ces of minerals: wat.er, sedim.ents, and liv.ing organ.isms[1-3]. Seve.ral stud.ies have been condu.cted on the pollu.tion of rivers with tra.ce elem.ents, and the overcontamination of the.se elem.ents has bec.ome a conc.ern for the hea.lth of the aqua.tic ecosy.stem [4,5]. Tra.ce elem.ents are hig.hly stable, pers.ist for long peri.ods, and are larg.ely unaff.ected by other environ.mental fact.ors due to the.ir abil.ity to form mult.iple comp.lex compo.unds. There.fore, it is diffi.cult to remove them[6,7]. Thus, this pollu.tion causes great environ.mental str.ess to aqua.tic organ.isms [8]. More.over, its examin.ation in rivers, lak.es, bent.hic organ.isms, and sedim.ents is vit.al to moni.tor toxi.city and non-biodegradability, whi.ch has been the subj.ect of seve.ral rese.arch wor.ks [9-11]. Bioaccum.ulation of tra.ce elem.ents can lead to tox.ic effe.cts on tiss.ues and org.ans. In fact, tra.ce elem.ents disrupt cell.ular eve.nts, including growth, prolife.ration, differen.tiation, damage- repai.ring proce.sses, and apopt.osis [12]. Alth.ough the tox.ic effe.cts of tra.ce elem.ents dep.end on the for.ms and the way of expo.sure. Interru.ptions of intrace.llular homeostasis incl.ude dam.age to lip.ids, prot.eins, enzy.mes, and DNA via the produ.ction of free radi.cals [13]. Sedim.ents act as a reser.voir for trace elements, whi.ch can subseq.uently accum.ulate in bottom-.feeding fish, mak.ing the.se organ.isms valu.able bioindi.cators of met.al pollu.tion. The.se fish can be potent.ially use.ful bioindi.cators for tracking met.al pollu.tion in aqua.tic enviro.nments. Furthe.rmore, tra.ce elem.ents in wat.er and sedi.ment aft.er ferti.lizer applic.ation rev.eal a compli.cated intera.ction between bio.tic and abio.tic varia.bles in the sys.tem [14, 15]. In fact, some trace elem.ents in the sedi.ment are endowed with physicoc.hemical properties that all.ow them to be remobi.lized and rele.ased back into the water col.umn via hydrodynamics, biogeoc.hemical proce.sses, and anthropogenic activ.ities [16, 17]. Furthe.rmore, the bioaccum.ulation of trace elem.ents in organ.isms can be pass.ive or selec.tive [18]. This stu.dy aims to ass.ess trace elem.ent lev.els in wat.er, sedim.ents, and fish tiss.ues in the Gha.raf River, Sha.tra Dist.rict, to deter.mine the ext.ent of contami.nation and its poten.tial environ.mental impact

Materials and Methods

The stu.dy was condu.cted on the Al-Ghar.raf Riv.er in Al-Sha.tra Dist.rict, Dhi Qar Govern.orate, sout.hern Iraq. Samp.les were colle.cted mont.hly for three mon.ths at the stu.dy stat.ion, from Nove.mber 2024 to January 2025. The stu.dy inclu.ded thr.ee typ.es of samp.les "wa.ter, sedi.ment and fish". Wat.er samp.les were colle.cted from the mid.dle of the riv.er usi.ng plas.tic (polye.thylene) 5 L bott.les with thr.ee repli.cates. A few dro.ps of HNO_3 were add.ed as a stabil.izing age.nt to stabi.lize the elem.ents in the wat.er. For the sedi.ment, the samp.les were colle.cted from the mid.dle of the riv.er usi.ng a grab samp.ler of Van Veen. They were kept in nyl.on bags and sto.red in boxes accor.ding to the IMRP. Fish samp.les were colle.cted from the stu.dy area usi.ng gill nets (25 mm mesh) and then pla.ced in an insul.ated cork conta.iner conta.ining ice unt.il they reac.hed the labor.atory. The tra.ce elements were extra.cted from the wat.er aft.er being dige.sted usi.ng the met.hod of APHA (19). The tra.ce elem.ents in the sedim.ents were extra.cted usi.ng the met.hod of Yi et al. (20). For fish samp.les, R.O..P.M.E. (21) met.hod was used to meas.ure tra.ce elem.ents. After prepa.ring the samp.les, they are analyzed with atomicab.sorption spectrophotometer dev.ice.

Statistical Analysis

SPSS vers.ion 23 was used for the statis.tical anal.ysis, and the mean ± stan.dard deviation (mean ± SD) was the outc.ome. The study gro.ups were comp.ared one.-way ANOVA

Results and Discussion

Tab.le 1 sho.ws the concent.rations of cadm.ium and lead in wat.er. The resu.lts sho.wed that the lowest cadmium concent.ration was (0.07 mg/L) in Janu.ary, whi.le the highest concent.ration was (0.23 mg/L) in December. Signif.icant differences were fou.nd betw.een the thr.ee mon.ths at a probability lev.el of $p \leq 0.05$. also the same tab.le sho.wed that the low.est zinc concent.ration was (1.61 mg/L) in Janu.ary, whi.le the high.est concent.ration was (3.27 mg/L) in Dece.mber. Signif.icant differences were fou.nd betw.een the thr.ee mon.ths at a probab.ility lev.el of $p \leq 0.05$.

Tab.le 1: "Concen.tration of trace elem.ents in wat.er dur.ing the stu.dy mon.ths" .

Months / Metals	Zinc (mg/L) Mean ±SD	Cadm.ium(mg/L) Mean ±SD
Nove.mber	2.53.±0.34 [b]	0.15.±0.003 [b]
Dece.mber	3.27.±0.21 [a]	0.23 ±0..006 [a]
Janu.ary	1.61.±0.18 [c]	0.07.±0.003 [c]
LSD	0.13	0.02

1. **Note:** Each val.ue repre.sents mean ± S.D values with non-id.entical supers.cript (a, b or c…etc), were consi.dered signifi.cantly differ.ences ($P \leq 0.05$).
2. **SD:** Stan.dard devia.tion.
3. **LSD:** Lea.st Signif.icant Diffe.rence

Tab.le 2 sho.ws the concent.rations of cadm.ium and zinc in the sedim.ents. The resu.lts sho.wed that the lowest average concent.ration of cadm.ium was (0.24 mg/L) in Janu.ary, whi.le the high.est aver.age concent.ration was (0.41 mg/L) in Dece.mber. Signif.icant differ.ences were fou.nd betw.een the thr.ee mon.ths at a probab.ility lev.el of $p \leq 0.05$. Tab.le 2 also sho.ws the concent.ration of zinc in the sedim.ents. The resu.lts sho.wed that the lowest average concent.ration of zinc was (2.04 mg/L) in Janu.ary, whi.le the high.est aver.age concent.ration was (3.72 mg/L) in Dece.mber. Signif.icant differ.ences were fou.nd betw.een the thr.ee mon.ths at a probab.ility lev.el of $p \leq 0.05$.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open

Vol. 10 No. 2 (2025): December
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Tab.le 2 : "Concen.tration of tra.ce elem.ents in sedim.ents dur.ing the stu.dy mon.ths" .

Months / Met.als	Zinc (mg/L) Mean ±SD	Cadm.ium(mg/L) Mean ±SD
Nove.mber	2.89.±0.21 [b]	0.34.±0.05 [b]
Dece.mber	3.72.±0.45 [a]	0.41 ±0.04 [a]
Janu.ary	2.04.±0.18 [c]	0.24.±0.01 [c]
LSD	0.12	0.08

- Leg.end as in tab.le (1)

Tab.le 3 sho.ws the cadm.ium and zinc concent.ration in fish tiss.ues. In the gil.ls, the lowest cadm.ium concent.ration was (0.13 mg/L) in January, whi.le the high.est concent.ration was (0.27 mg/L) in Dece.mber. Signif.icant differ.ences were fou.nd betw.een the thr.ee mon.ths at a probab.ility lev.el of $p \leq 0.05$. In liv.er the, the lowest cadm.ium concent.ration was (0.18 mg/L) in January, whi.le the high.est concent.ration was (0.30 mg/L) in Dece.mber. Signif.icant differ.ences were fou.nd betw.een the thr.ee mon.ths at a probab.ility lev.el of $p \leq 0.05$. In the musc.les, the low.est cadm.ium concent.ration was (0.090 mg/L) in January, whi.le the high.est concent.ration was (0.25 mg/L) in December. Signif.icant differ.ences were fou.nd betw.een the thr.ee mon.ths, at a probab.ility lev.el of $p \leq 0.05$. The same tab.le sho.ws zinc concent.ration in fish tiss.ues. In the gil.ls, the low.est zinc concent.ration was (1.95 mg/L) in Janu.ary, whi.le the high.est concent.ration was (3.62 mg/L) in Dece.mber. Signif.icant differ.ences were found betw.een the three mon.ths at a probab.ility lev.el of $p \leq 0.05$. In liv.er the low.est zinc concent.ration was (1.95 mg/L) in Janu.ary, whi.le the high.est concent.ration was (3.58 mg/L) in Dece.mber. Signif.icant differ.ences were fou.nd betw.een the thr.ee mon.ths at a probab.ility lev.el of $p \leq 0.05$. In the musc.les, the low.est zinc concent.ration was (1.73 mg/L) in January, whi.le the high.est concent.ration was (3.48 mg/L) in Dece.mber. Signif.icant differ.ences were fou.nd betw.een the thr.ee mon.ths at a probab.ility lev.el of $p \leq 0.05$.

Tab.le 3: "Concent.rations of zinc and cadm.ium in tiss.ues (gi.lls, Kidn.eys and musc.les) dur.ing the study mon.ths"

	Zinc (mg/L) Mean ±SD			Cadmi.um(mg/L) Mean ±SD		
Months / Site	Musc.les	liv.er	Gil.ls	Musc.les	liv.er	Gil.ls
Nove.mber	0.13±0.03 [b]	0.26.±0.04 [b]	0.16.±0.02 [b]	2.57.±0.41 [b]	2.74.±0.32 [b]	2.67.±0.25 [b]
December	0.25 ±0.01 [a]	0.30 ±0.07 [a]	0.27 ±0.10 [a]	3.48.±0.16 [a]	3.62.±0.53 [a]	3.58.±0.37 [a]
Janu.ary	0.09.±0.001 [c]	0.18.±0.03 [c]	0.13.±0.005 [c]	1.73.±0.21 [c]	1.95.±0.22 [c]	2.01.±0.18 [c]
LSD	0.04	0.04	0.02	0.10	0.14	0.16

- Leg.end as in tab.le (1)

The stu.dy revealed elevated concent.rations of cadm.ium and zinc in wat.er, sedim.ents, and fish tissues—including gil.ls, kid.ney, and muscles—throughout the samp.ling per.iod. Aqua.tic ecosy.stems oft.en act as fin.al recep.tors for vari.ous contaminants, partic.ularly trace met.als that threaten environ.mental and hum.an hea.lth (22). Alth.ough met.als may origi.nate from natu.ral geolo.gical weath.ering, anthrop.ogenic input.s—such as industrial discharge, agricu.ltural activ.ities, and inade.quate waste disposal—generally repre.sent the dominant sour.ces of enric.hment in aqua.tic enviro.nments (23). Addit.ional contrib.utions may ari.se from atmospheric depos.ition and uncont.rolled waste release, both of whi.ch can increase met.al loa.ds (24,25). Because organ.isms in aqua.tic habi.tats rem.ain in constant cont.act with their enviro.nment, the effe.cts of met.al pollu.tion are more prono.unced, lead.ing to bioaccum.ulation and poten.tial biomagni.fication thro.ugh food webs (26,27). Fish are wid.ely used as bioindi.cators due to the.ir capa.city to assim.ilate metals from both wat.er and sedim.ents (28,29). Giv.en the ris.ing depen.dence on fish as a nutritional reso.urce, evalu.ating met.al concent.rations is essen.tial to ensure food saf.ety and ass.ess poss.ible hea.lth ris.ks (30-32). Furthe.rmore, sedim.ents func.tion as major sin.ks for trace met.als and prov.ide an impor.tant rec.ord of long.-term contami.nation in aqua.tic syst.ems (33-35)..

Conclusion

The find.ings of the pres.ent stu.dy conf.irm that the aqua.tic enviro.nment is expo.sed to consid.erable inp.uts of cadm.ium and zinc, lead.ing to the.ir accumu.lation in sedim.ents and fish tissues. The.se resu.lts highl.ight the urg.ent need for stri.cter environ.mental monit.oring and impr.oved manag.ement pract.ices to red.uce metal contami.nation and prot.ect ecosy.stem and public hea.lth

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

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ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo