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ORIGINAL RESEARCH PAPER

Determining heavy metal and developing model for concentration in the feathers of house sparrow (Ni, Pb,Cd) in Tehran
Determining heavy metal concentration in the feathers of house sparrow

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ABSTRACT

Heavy metals cause many problems in living organisms. Using living organism as a bio indicator is a useful way to show environment conditions. In this paper, bioaccumulation of heavy metals in house sparrow feather was studied. The house sparrow is distributed in many parts of the world. The house sparrow lives in urban and rural areas. Due to living in residential areas, it is affected by man-made pollutants. The main source of air pollution in Tehran is fuel combustion in car engines. It seems that air pollution somehow accumulates in the body of urban birds. The house sparrow has been selected as a biological indicator in Tehran. Sample point were chosen in north, south, west and east of Tehran. In each area 10 samples were chosen. Amount of heavy metals in feathers measured by ICP. Zoning was done using GIS. According to result amount of nickel is higher than cadmium and lead. The accumulation of heavy metals in the feather tissue depends on where the bird lives. The highest amount of lead, nickel and cadmium was 2.89, 451 and 25.9 ppb. The lowest amount of lead, nickel and cadmium was 0.88, 11.59 and 0.54 ppb. Result indicates that house sparrow could be used as a bio indicator of heavy metals in urban areas. The curve fitting application in MATLAB is used and shows the relation between heavy metal concentration in soil and concentration in feathers to predict amount of muscle concentration.

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1. Background

Development of industries caused wide spread of various kinds of pollutants. In urban area transportation is a major source of pollutant, like petroleum hydrocarbons, heavy metals and so on (Jalilzadeh Yengejeh et al., 2014; Masoumi et al., 2020; Tabari et al., 2021) . Heavy metals are one of the most important environmental pollutants and their toxicity is an environmental problem. Some of them have cumulative properties and accumulate and store by living tissues. Heavy metals settle down on the soil and enter the food chain. Heavy metal retention time in soil is longer than other environmental media (Babaei et al., 2017; Khalili Arjaghi et al., 2020; Farsani et al., 2022; lassat,2022).

House sparrow or common sparrow or city sparrow with the scientific name Passer domesticus is a species of sparrow that mainly lives in urban areas in large numbers. The most populous sparrows in Tehran are of the "house sparrow" species, which make up about 90% of the sparrow population in Tehran. It has been seen that sparrows live in polluted places in many countries (albayrak & pekgoz,2021; Mboua et al., 2023).

Various factors affect the accumulation of heavy metal in bird feathers like: diet, age, gender and so on (Fataei, et al., 2010;Varagiya et al., 2022). In this study, the amount of lead, cadmium and nickel in the feather of house sparrow were measured.

Lead is a natural element found in small quantities in the Earth's crust(Bayrami et al., 2020; Fazeli et al., 2019; Gazijahani et al., 2017; Hadi Bonab et al., 2020). Lead is used in crystal, paint, ceramics, pipe, solder, gasoline, battery, ammunition and cosmetics. Lead enters the human and animal body in two ways and causes poisoning; One by entering the food chain by feeding the elements of the chain and the other by breathing in lead -contaminated air. Through nutrition, concentrations of lead enter the human body and organisms.

Cadmium is a natural element in the Earth's crust. Cadmium is used in the manufacture of batteries, especially nickel-cadmium batteries, plating, coatings, stabilizing materials in plastics and colors. Forest fires and volcanoes, industrial activities, wastewater discharge, industrial waste, phosphate fertilizers are sources of cadmium emissions. The amount of cadmium absorption in food is depends how the animals are fed. In 2004, the World Health Organization considered the maximum permissible amount of cadmium for agricultural soils to be about 0.2 mg/kg. Cadmium is a relatively mobile metal and its amount in the environment is low. Cadmium is present in phosphate fertilizers and enters the environment from metal smelting industries.

Industrial uses of nickel include steel, plating, colors, and ceramics. Low values are needed to produce red blood cells in the human body, although in high values it can be somewhat toxic. Nickel affects the tissue of the brain, liver, kidney, bones, heart and endocrine glands) Duda-Chodak and Blaszczy, 2008; Khayatnezhad and Nasehi, 2021, Wang et al., 2022).

The house sparrow can be an indicator of environmental conditions due to its high adaptability to urban environments. Therefore. In this study we measured the amount of aforementioned heavy metals in feather of house sparrow to act as a bio indicator for surveying the amount of pollution.

2. Materials and Methods

Our statistical population was the whole population sparrows of Tehran which was not practical. The sample size was calculated using Cochran formula. Sparrow feathers were collected from different parts of Tehran. For ethical reasons, the number of samples was limited. 10 nests were considered from each park. Using the GPS, the geographic location of the sampling area was determined. Sampling was done in different areas during the summer of 2022. Parks were selected for sampling the nest, because parks have denser vegetation than other places of the city. Feathers gathered from sparrow nest. The feathers were dried and powdered. The sample was digested in 5 ml of sulfuric acid and placed on a hot plate for 3 hours. The sample was diluted and injected into the device. Measurement of heavy metals was performed using the ICP-OES model VISTA MPX manufactured by Varian Australia. MATLAB software was used for development model for relation between concentration heavy metals in soil and feathers to predict muscle concentrations.

Table 1. Geographical location of sampling stations

Geographical location	Station
35.755139, 51.376501	Fadak park
35.808673, 51.471781	Niavaran park
35.683016, 51.409759	City park(shahr)
35.753293, 51.423348	Haghani park

3. Results

Figure (1) indicates heavy metals concentration in feathers of sparrow in various part of Tehran. It shows the accumulation of metals in the feathers of sparrows in the various part of Tehran city. The highest accumulation is related to nickel and the lowest amount of the desired metals is related to lead. Among the metals considered in this research, cadmium is more than lead and much less than nickel. Lead is stored in feather tissues ((Jayakumar and Muralidharan, 2011), It is shown in figure (2) that the accumulation values of each metal in house sparrows feather of different regions are different. This difference

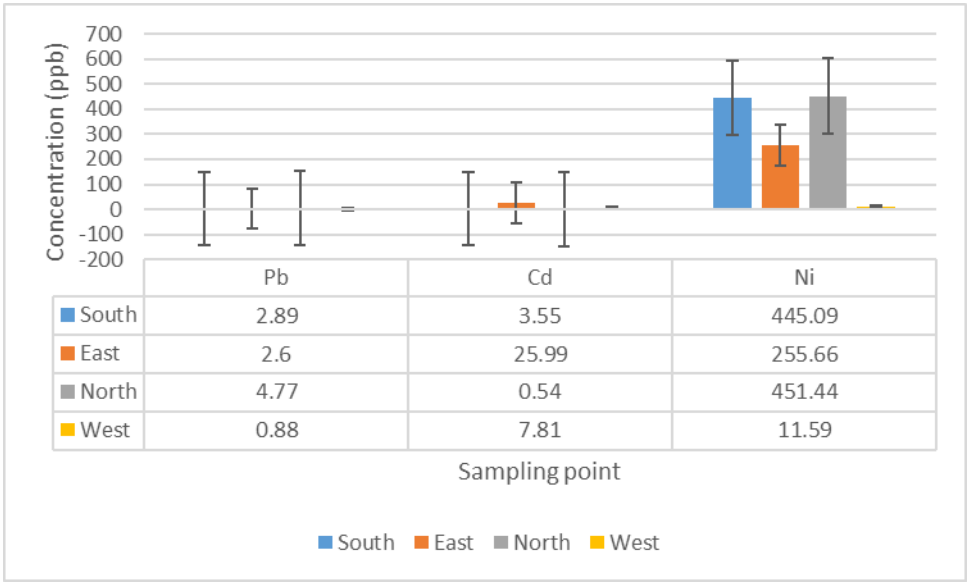

Fig 1. heavy metals concentration in feathers of sparrow in various parts of Tehran

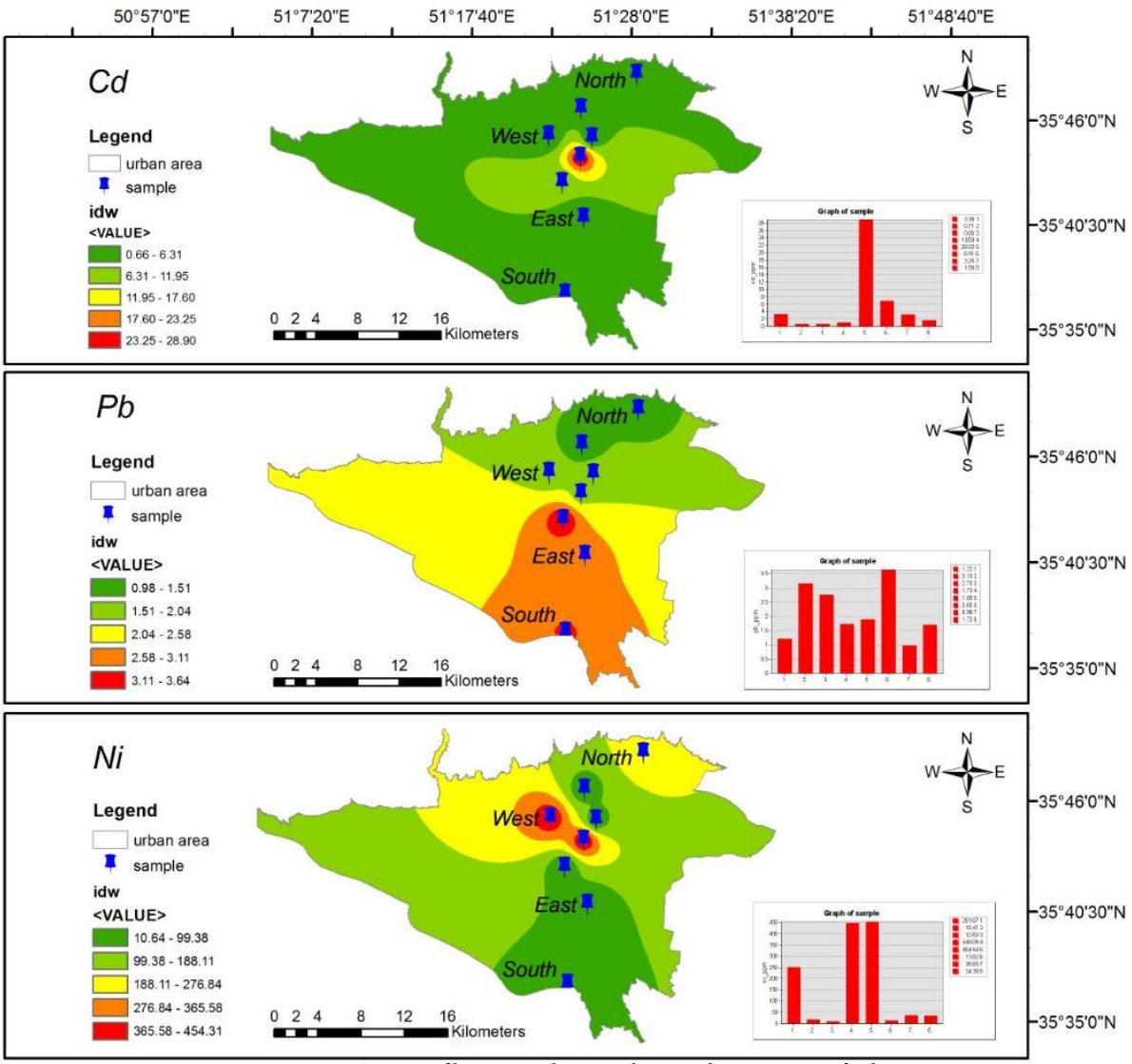

Fig 2. Zoning of heavy metal accumulation in house sparrow feathers

is due to the accumulation of the mentioned metals in different areas under investigation. Concentration of nickel, cadmium and lead are different in mentioned part of Tehran's.

Cadmium is more than 0.05 and on the other hand,

Table 1. t test for equality of means

t test for equality of means						Report Number
Confidence Interval		Difference mean	sig.value	Degrees of Freedom	t	
Upper	Lower					
1653.35	1343.25	1498.300	0.000	19	20.225	
14.95566	-0.97636	6.989650	0.082	19	1.836	Cd
-10.3291	-11.2849	-10.80700	0.000	19	-47.327	Pb
172.78031	4.92709	88.853700	0.039	19	2.216	Ni

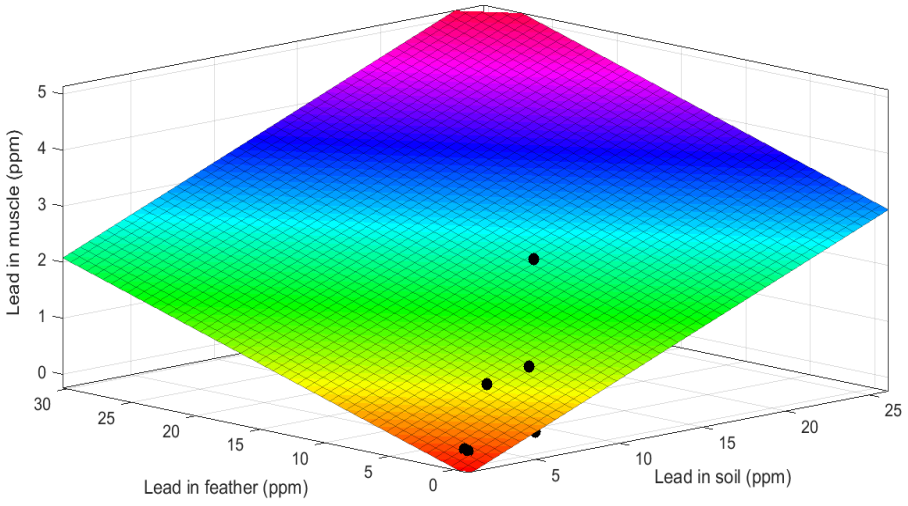

Fig 3. Lead concentration

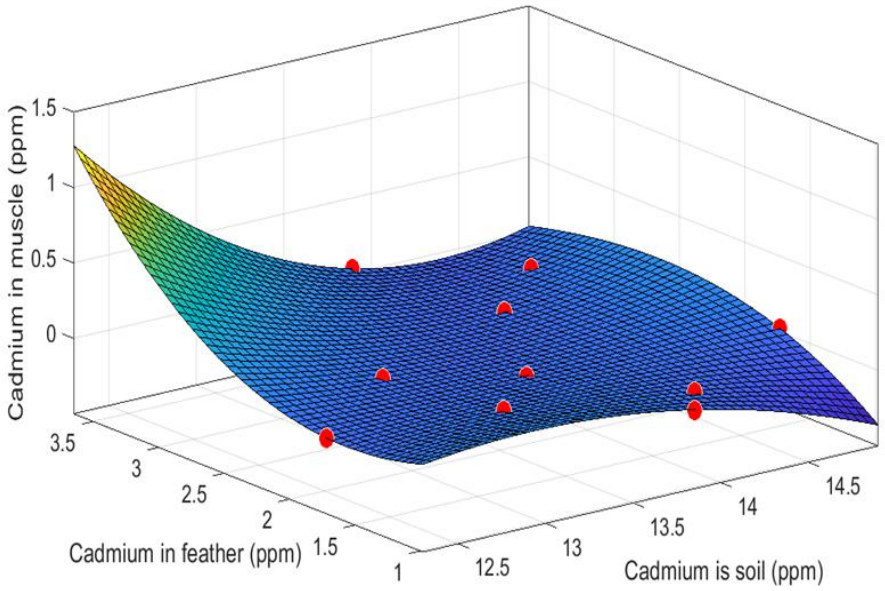

Fig 3. Cadmium concentration

the confidence interval includes zero, that is, Cd is equal to the average value.

The significance level for Pb, Ni is less than 0.05 and on the other hand, the confidence interval includes zero, Therefore, we can reject the assumption that the average is equal to the average value, that is, Cd is not equal to the average value, now considering that:

For Pb, the lower and upper confidence intervals are negative, so it is lower than the average value. For Ni, the lower and upper confidence intervals are positive, so it is more than the average value.

The reason we use the one-group T-test is that we want to compare this value with a constant value which is its standard value.

Linear model Poly23:

sf(x,y) = p00 + p10*x + p01*y + p20*x^2 + p11*x*y + p02*y^2 + p21*x^2*y + p12*x*y^2 + p03*y^3

Coefficients (with 95% confidence bounds):

(p00 = -0.7026 (-7.751, 6.346)
(p10 = 0.468 (-3.955, 4.891)
(p01 = 0.1543 (-12.79, 13.1)
(p20 = -0.08879 (-0.7539, 0.5763)
(p11 = -0.03658 (-2.328, 2.255)
(p02 = 0.1454 (-4.817, 5.108)
(p21 = 0.03402 (-0.2971, 0.3651)
(p12 = -0.0655 (-1.075, 0.9439)

In order to determine the concentration of lead in muscle, the curve fitting application in MATLAB was used. This process involves creating a mathematical model that accurately represents the relationship between two sets of variables: the lead concentration in soil and lead concentration in a feather, and the lead concentration in muscle. MATLAB's curve fitting tool allows the user to define a function that describes the relationship between the independent variables (lead in soil and lead in feature) and the dependent variable (lead in muscle). The parameters of this function are then adjusted to best fit a set of observed data points. Once the best-fitting model is determined, the related equation is also presented for reference and further analysis. This allows for more accurate predictions of lead concentration in muscle based on the lead concentrations in soil and lead in feature

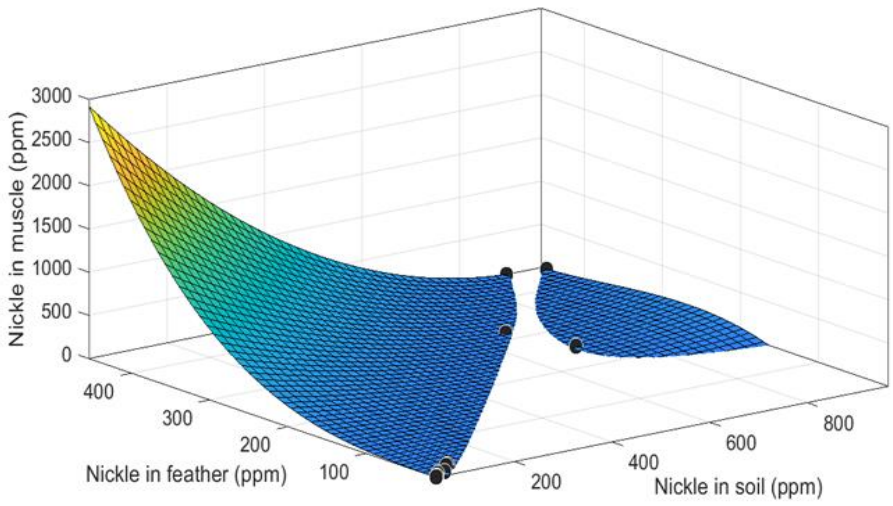

Fig 3. Nickel concentration

4.Discussion

It seems that a significant amount of heavy metals is released into the atmosphere by the traffic of Tehran city and can accumulate in the soil, which eventually becomes an available source of heavy metals. Heavy metals enter the soil from various sources such as water, air and… (Abbasi& Afrous, 2023). Industries and vehicles are the main source of nickel, lead and cadmium(Ajami et al., 2015; Gooran Ourimi, & Nezhadnaderi, 2020; Raazi Tabari et al., 2020). It can be said that the land use of the area plays an important role in the distribution of heavy metals in the environment. The amount of nickel is very high in the central and western regions which is at a critical level. On the other hand, the amount of nickel is at the lower amount in southern and eastern part of Tehran. It can be justified that amount of concentrations of heavy metals in different parts of Tehran depends on metals behavior, density of vegetation and distance from main streets. Tehran's air pollution is the main cause of the entry of heavy metals into the environment (Abbasi et al.;2017), so distance from heavy traffic areas affect

the concentration of heavy metals in soil. Nickel and Vanadium are indicators of petroleum pollution, which are probably caused by vehicle fuel in many places. Air pollution is high near many high-traffic areas of Tehran, and the deposition of soot and pollutants on the food used by birds causes an increase in heavy elements in birds. Ingestion of nickel by birds and wildlife affects their respiratory system and leads to asthma and also damages DNA. According to the obtained results, the sparrow feather can be used as an Environmental pollution index. Some researches state that the amount of nickel absorption in birds of polluted areas is higher than that of mammals (Outridge & Scheuhammer,2011). The high level of nickel in the environment can be related to being close to electronic factories in some areas. The land use an important role in the distribution of heavy metals in the environment.

Cadmium are high in central areas of Tehran and low in other areas. Other reserchers obtained the same result (Abbasi et al.;2017). The amount of cadmium can be attributed to the use of fertilizers and pesticides. According to Burger (2008) the number of differences may be related to things like atmospheric deposition, local emission, bird species and how heavy metal is exposed (Burger et al.,2008). Wild birds, which are closely related to humans, have the highest risk of contamination and are an important environmental indicator of environmental pollution. Crows, house sparrows, nightingales, and pigeons are among these birds (Aziz et al.,2021). Bioaccumulation Cadmium can be related to the use of fertilizers and pesticides (Ajami et al., 2015; Hajjabbari et al., 2016; Ya et al., 2019). According to Hahn et al.,1993, The bioaccumulation of lead and cadmium in bird's feather has been related to air pollution. High amounts of cadmium cause oxidative stress in birds (Karimi et al., 2018). Cadmium accumulation is higher in aquatic animals (Fatemi & Khoramnejadian,2016). Lead is low in most areas except in the south of the city because it has been removed from gasoline for years.

The amount of lead is very high in the south and east of Tehran. In the north and west of Tehran, the amount of lead is very low.

Jasper (2013) mentions the reason for choosing it as a biological indicator in birds is the correlation between the high level of pollutants in bird food and the accumulation in bird tissues (Jaspers et al., 2013).

Air pollution is high near many high-traffic areas of Tehran. The deposition of soot and pollutants on the food used by birds can cause the increase of heavy elements in birds. Birds are affected by man-made pollutants in urban and rural areas, This has been seen in other studies (Sheybanifar et al.,2015).

Bird feathers contain sulphurous proteins, so heavy metals are more concentrated in the feathers(Burger et al.,2008).

It seems that a significant amount of heavy metals is released into the atmosphere by means of transport in Tehran and can accumulate in the soil, which eventually becomes an available source of heavy metals. This is also seen in the research (Manta et al.,2002).

5.Conclusion

Growing cities and industrialization caused environmental pollutions. Fossil fuel is the source of various pollutants in the world. Heavy metals concentrate in the different parts of living organisms and transfer in the food chain.

Bird feathers act as biological indicators and show environmental conditions.

The current research showed that the accumulation of heavy metals in feathers is an indicator of the environment and these elements are accumulated. The lowest concentration of lead in fill was 0.88

ppb in the west and the highest was 2.89 ppb in the south. The lowest concentration of cadmium was 0.54 in the north and the highest was 25.99ppb in the east. The lowest concentration of nickel was 11.59 ppb in the west and the highest was 451 ppb in the north.

By MATLAB Linear model Poly23 we can predict the relation between the amount of soil heavy metal concentrations with muscle and feather concentrations.

References

Abbasi, S., & Afrous, A. (2023). Potential adverse effects of heavy metals in Ahvaz oil field. Anthropogenic Pollution, (), -. doi: 10.22034/ap.2023.1962491.1132

Abbasi, S., Ali Mohammadian, H., Hosseini, S. M., Khorasani, N., Karbasi, A. A., & Aslani, A. (2017). The Concentration of Heavy Metals in Precipitated Particles on the Leaves of Street Side Trees in the Urban Environments (Tehran– Iran). Anthropogenic Pollution, 1(1), 1-8.

Ajami, F., & Fataei, E. (2015). Determination of Heavy Metals level (lead, cadmium, chrome) in waters of Meshkinshahr River for agricultural use. Advances in Bioresearch, 6(3), 12-15.

Ajami, F., Fataei, E., & Branch, A. (2015). Environmental Effects of Heavy Metals in Determining the Quality of Surface Water for Agricultural Purposes in Meshginshahr. Indian Journal Of Natural Sciences, 5(30), 6887.

Aziz, B., Zubair, M., Irshad, N., Ahmad, K. S., Mahmood, M., Tahir, M. M., Shah, K. H., & Shaheen, A. (2021). Biomonitoring of Toxic Metals in Feathers of Birds from North-Eastern Pakistan. Bulletin of environmental contamination and toxicology, 106(5), 805–811.

Babaei, A. A., Ghanbari, F., & Yengejeh, R. J. (2017). Simultaneous use of iron and copper anodes in photoelectro-Fenton process: concurrent removals of dye and cadmium. Water Science and Technology, 75(7), 1732-1742.

Bayrami, N., Fataei, E., Kharrat Sadeghi, M., & Javanshir Khoei, A. (2020). Evaluation of bioaccumulation of lead metal pollutant in two biotic and abiotic compartments of the Caspian Sea coastal sediments. Journal of Marine Biology, 12(3), 1-14.

Burger J, Gochfeld M, Jeitner C, Snigaroff D, Snigaroff R, Stamm T, Volz C (2008) Assessment of metals in down feathers of female common eiders and their eggs from the Aleutians: arsenic, cadmium, chromium, lead, manganese, mercury, and selenium. Environ Monit Assess 143:247–256.

Burger, J., Veitch, C. R. and Gochfeld, M.: 1994, 'Locational differences in metal concentrations of feathers of Australasian gannet (Morus serrator) in New Zealand', Envir. Monit. Assess. 32, 47–57.

Duda-Chodak A, Blaszczyk U (2008) The impact of nickel on human health. J Elementol 13(4):685–696

Esteban M, Castaño A,.(2009). Non-invasive matrices in human

biomonitoring: a review Environ. Int. 35, 2, 438 – 449.
Farsani, M. H., Yengejeh, R. J., Mirzahosseini, A. H., Monavari, M., Hassani, A. H., & Mengelizadeh, N. (2022). Effective leachate treatment by a pilot-scale submerged electro-membrane bioreactor. Environmental Science and Pollution Research, 29, 9218–9231.
Fataei, E, Monavari, SM, Hasani, AH Karbasi, AR Mirbagheri SA.(2010) Heavy metal and agricultural toxics monitoring in Garasou river in Iran for water quality assessment.Journal Asian Journal of Chemistry, 22(4):2991-3000
Fatemi F, Khoramnejadian S. Investigation of Cadmium and Arsenic Accumulation in Portunus pelagicus along the Asalouyeh Coast, Iran. J Earth Environ Health Sci 2016;2:34-8
Fazeli, S., Abdollahi, N., Imani Marrani, H., Malekizade, H., & Hosseinzadeh, H. (2019). A new robust adaptive decentralized tube model predictive control of continuous time uncertain nonlinear large-scale systems. Cogent Engineering, 6(1), 1680093.
Gazijahani, F. S., Hosseinzadeh, H., Tagizadeghan, N., & Salehi, J. (2017, 19-20 April 2017). A new point estimate method for stochastic optimal operation of smart distribution systems considering demand response programs. Paper presented at the 2017 Conference on Electrical Power Distribution Networks Conference (EPDC).
Ghomi Avili, F. Removal of Heavy Metals (Lead and Nickel) from Water Sources by Adsorption of Activated Alumina. Anthropogenic Pollution.(2021), 5(2), 1-7.
Gooran Ourimi, H., & Nezhadnaderi, M. (2020). Comparison of the application of Heavy metals adsorption methods from aqueous solutions for development of sustainable environment. Anthropogenic Pollution, 4(2), 15-27.
Hadi Bonab, S., Abazari, R., Bagheri Vakilabad, A., & Hosseinzadeh, H. (2020). Generalized metric spaces endowed with vector-valued metrics and matrix equations by tripled fixed point theorems. Journal of Inequalities and Applications, 2020, 1-16.
Hahn E, Hahn K, Markus Stoeppler M.(1993). Bird feathers as bioindicators in areas of the German environmental specimen bank - bioaccumulation of mercury in food chains and exogenous deposition of atmospheric pollution with lead and cadmium, Science of The Total Environment, 139–140, 259-270.
Hajjabbari, S., & Fataei, E. (2016). Determination cadmium and lead pollution resources of Ardabil Plain underground waters. Open Journal of Ecology, 6(9), 554-561.
Jalilzadeh Yengejeh, R., Sekhavatjou, M., Maktabi, P., Arbab Soleimani, N., Khadivi, S., & Pourjafarian, V. (2014). The Biodegradation of Crude Oil by Bacillus subtilis Isolated from Contaminated Soil in Hot Weather Areas. International Journal of Environmental Research, 8(2), 509-514. doi: 10.22059/ijer.2014.744
Jaspers Veerle L.B. , Adrian Covaci, Dorte Herzke, Igor Eulaers, Marcel Eens.2019. Bird feathers as a biomonitor for environmental pollutants: Prospects and pitfalls, TrAC Trends in Analytical Chemistry, 118, 223-226.
K. Honda, D.P. Lee, R. Tatsukawa Lead poisoning in swans in Japan Environ. Pollut., 65 (1990), pp. 209-218.
Karimi O, Hesaraki S, Mortazavi S P. The Effect of Cadmium on the Ultrastructure and Metallothionein Levels in the Liver and Kidneys of Japanese quail. IJT 2018; 12 (2) :21-25
Khalili Arjaghi, S., Ebrahimzadeh Rajaei, G., Sajjadi, N., Kashefi Alasl, M., & Fataei, E. (2020). Removal of Mercury and Arsenic Metal Pollutants from Water Using Iron Oxide Nanoparticles Synthesized from Lichen Sinensis Ramalina Extract. Journal of Health, 11(3), 397-408.
Khalili Arjaghi, Sh., Ebrahimzadeh Rajaei, Gh., SAJJADI, N., KASHEFI ALASL, M., & FATAEI, E.. (2020). Removal of Mercury and Arsenic Metal Pollutants fromWater Using Iron Oxide Nanoparticles Synthesized from Lichen Sinensis Ramalina Extract. JOURNAL OF HEALTH AND HYGIENE, 11(3), 397-408.
Khayatnezhad, M. & nasehi, F. (2021). Industrial pesticides and a methods assessment for the reduction of associated risks: a Review. Advancements in Life Sciences, 8, 202-210.
Lasat, M.M. 2002. Phytoextraction of toxic metals: A review of biological mechanisms. Journal of Environmental Quality. 31(1): 109-120.
Manta DS, Angelone M, Bellanca A, Neria R, Sprovieria M.2002.Heavy metals in urban soils a case study from city of Palermo (Sicily), Italy. Sci Total Environ..2300(1–3):229–243.
Markowski M, Kalinski A, Skwarska J, Wawrzyniak J, Banbura M, Markowski J, Zielinski P, Banbura J (2013) Avian feathers as bioindicators of the exposure to heavy metal contamination of food. Bull Environ Contam Toxicol 91:302–305
Masoumi, A., & Yengejeh, R. J. (2020). Study of chemical wastes in the Iranian petroleum industry and feasibility of hazardous waste disposal. Journal of Environmental Health Science and Engineering, 18(2), 1037-1044.
Mboua, E. ., Bitondo, D. ., Tabi, F. O. ., & Boukong, A. . (2023). Availability of exchangeable potassium due to cocoa pods husk and coffee wastes amended with urea and impact on some other soil physico-chemical properties in a ferralsol of west Cameroon . Current Research in Agricultural Sciences, 10(1), 22–32. https://doi.org/10.18488/cras.v10i1.3366.
Millaku, Lulzim & Imeri, Resmije & Trebicka, Artan. (2014). House sparrow (Passer domesticus) as bioindicator of heavy metals pollution. European Journal of Experimental Biology. Voume 4. 77-80.
Outridge, P. M. and Scheuhammer. A. M. 2011. Bioaccumulation and toxicology of nickel: implications for wild mammals and birds. Environmental Reviews. 1(2): 172-197.
R. Jayakumar, S. Muralidharan. Metal contamination in select species of birds in Nilgiris District, Tamil Nadu, India. Bull Environ. Contam. Toxicol., 87 (2011), pp. 166-170.
Raazi Tabari, M. R., Sabzalipour, S., Peyghambarzadeh, S. M., & Jalilzadeh, R. (2020). Vapor Loss of Volatile Organic Compounds (VOCs) from the Shipping Port of Abadan Petroleum Refinery. Pollution, 6(4), 863-878.
Sheybanifar, F., Mortazavi, S., & Mirsanjari, M. M. (2014). The Study of Heavy Metal accumulation (Zn, Cu, Pb and Cd) in muscle of Great White Heron (Egretta alba) in Hara Biosphere Reserve. Journal of Environmental Studies, 40(4), 929-936.
Tabari, M. R. R., Sabzalipour, S., Peyghambarzadeh, S. M., & Jalilzadeh, R. (2021). Dispersion of volatile organic compounds in the vicinity of petroleum oroducts storage tank. Environmental Engineering & Management Journal (EEMJ), 20(7).
Tamer Albayrak, Asuman Karadeniz Pekgöz(2021), Heavy metal effects on bird morphometry: A case study on the house sparrow Passer domesticus, Chemosphere,276, 130056.
Varagiya, D., Jethva, B. & Pandya, D. Feather heavy metal contamination in various species of waterbirds from Asia: a review. Environ Monit Assess 194, 26 (2022).
Wang, S., Ma, J., Li, W., Khayatnezhad, M. & Rouyendegh, B. D. (2022). An optimal configuration for hybrid SOFC, gas turbine, and Proton Exchange Membrane Electrolyzer using a developed Aquila Optimizer. International Journal of Hydrogen Energy, 47, 8943-8955.
Ya J, Ju Z, H Wang H, Zhao H(2019). Exposure to cadmium induced gut histopathological damages and microbiota alterations of Chinese toad (Bufo gargarizans) larvae, Ecotoxicology and Environmental Safety,180,449-456.
Khalili Arjaqy Sh, Fataei E(2015) Assessment of Waste Management in Health Centers in the city of Ardabil, Biological Forum 7 (2), 117
Kharrat Sadeghi, M., & Maleki, A. (2022). The effect of source separation training on municipal waste reduction: A case study. *Anthropogenic Pollution*, *6*(2), 10-15. doi: 10.22034/ap.2022.1966027.1135
Khayatnezhad, M., E. Fataei and A. Imani (2023). "Integrated modeling of food–water–energy nexus for maximizing water productivity." Water Supply.
Kirama, A., & Mayo, A. W. (2016). Challenges and prospects of private sector participation in solid waste management in Dar es Salaam City, Tanzania. *Habitat International*, 53, 195-205.
Lee, S., & Paik, H. S. (2011). Korean household waste management and recycling behavior. *Building and Environment*, 46(5), 1159-1166.
Lu, L. T., Hsiao, T. Y., Shang, N. C., Yu, Y. H., & Ma, H. W. (2006). MSW management for waste minimization in Taiwan: The last two decades. *Waste Management*, 26(6), 661-667.
Metin, E., Eröztürk, A., & Neyim, C. (2003). Solid waste management

practices and review of recovery and recycling operations in Turkey. *Waste management*, 23(5), 425-432.

Mohammad Alipour, S., Fataei, E., Nasehi, F., & Imani, A. A. (2022). Vermicompost quality and earthworm reproduction in different organic waste substrates. International Journal of Recycling Organic Waste in Agriculture, (), -. doi: 10.30486/ijrowa.2022.1944906.1371

Ohri, A., & Singh, P. K. (2009). Private Sector Participation in Municipal Solid Waste Management in India: Observation and Options. *Proceedings of RAWM*, 141.

Ojaghi, A., Fataei, E., Garibi Asl, S. & Imani, A. A. 2021. Construction, design and testing of infectious waste decontamination device by mechanical and chemical methods, Imam Khomeini Hospital, Sarab, Iran: A case study. Journal of Health Sciences and Surveillance System, 9, 184-190.

Otitoju, T. A. (2014). Individual attitude toward recycling of municipal solid waste in Lagos, Nigeria. *American Journal of Engineering Research*, 3(7), 78-88.

Portney, K. (2005). Civic engagement and sustainable cities in the United States. Public Administration Review, 65(5), 579-591.

Samadi Khadem R, Fataei E, Joharchi P, Ramezani ME, (2020) Site selection of hazardous waste landfill: A case study of Qazvin Province, Journal of Health(In Persian), 11 (3), 281-298

Seiied safavian ST, Fataei E(2012) Designing Storage, Collection and Transportation System of Municipal Waste, Int. Proc. Chem., Biol. Environ. Eng 42, 40-45

Seiied Safavian ST, Fataei E, Ebadi T, Mohamadian A.(2015) Site Selection of Sarein's Municipal Solid Waste Landfill Using the GIS Technique and SAW Method, International Journal of Environmental Science and Development 6 (12), 934-341.

Seiied Safavian ST, Fataei E, Hassanpour H, Tolou I (2014) Automatic Recycling Waste Receive System in Public Areas., Advances in Bioresearch 5 (1)

Shoary Bavil Oliaei A, Fataei E,(2016) Breakdown of urban waste repository location using GIS (Case study District 3 region 1 Tabriz), Ecology, Environment and Conservation, 22, 551-557

Sun, X. and M. Khayatnezhad (2021). "Fuzzy-probabilistic modeling the flood characteristics using bivariate frequency analysis and α-cut decomposition." Water Supply 21(8): 4391-4403.

Thaçi, B. and S. Gashi (2023). "Study of Cd (II) ions biosorption from aqueous solution by wheat bran." Water and Environmental Sustainability 3(2): 32-42.

Tilaye, M., & Van Dijk, M. P. (2014). Private sector participation in solid waste collection in Addis Ababa (Ethiopia) by involving micro-enterprises. *Waste Management & Research*, 32(1), 79-87.

Turan, N. G., Çoruh, S., Akdemir, A., & Ergun, O. N. (2009). Municipal solid waste management strategies in Turkey. *Waste Management*, 29(1), 465-469.

United Nations Human Settlements Programme. (2010). Solid Waste Management in the World's Cities: Water and Sanitation in the World's Cities 2010. Earthscan.

Van Speier, J. (2009). Citizen participation influencing public decision making: Brazil and the United States, 6(1): 156-159.

Wang, C., Y. Shang and M. Khayatnezhad (2021). "Fuzzy stress-based modeling for probabilistic irrigation planning using Copula-NSPSO." Water Resources Management 35: 4943-4959.

Wang, S., J. Ma, W. Li, M. Khayatnezhad and B. D. Rouyendegh (2022). "An optimal configuration for hybrid SOFC, gas turbine, and Proton Exchange Membrane Electrolyzer using a developed Aquila Optimizer." International Journal of Hydrogen Energy 47(14): 8943-8955.

Zhang, D., Huang, G., Yin, X., & Gong, Q. (2015). Residents' waste separation behaviors at the source: Using SEM with the theory of planned behavior in Guangzhou, China. *International journal of environmental research and public health*, 12(8), 9475-9491.

Zhang, J., M. Khayatnezhad and N. Ghadimi (2022). "Optimal model evaluation of the proton-exchange membrane fuel cells based on deep learning and modified African Vulture Optimization Algorithm." Energy Sources, Part A: Recovery, Utilization, and Environmental Effects 44(1): 287-305.

Zile Huma, G. L., Syed Lakhte Hyder (2021). "Promoting Resilience and Health of Urban Citizen through Urban Green Space." Water and Environmental Sustainability 1(1): 37-43.