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SPATIAL AND TEMPORAL VARIATION OF *IN-VITRO* BIOACCESSIBILITY OF CHROMIUM IN PLAYGROUND SOILS OF ANCIENT BELL METAL INDUSTRIAL TOWN, KHAGRA, WEST BENGAL

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Abstract: Present study was designed to study the seasonal variation of Chromium (Cr) in playground soil of Khagra City located in West Bengal, India from 16 different playgrounds. Sequential extraction techniques had been carried out to evaluate the relative dispersal of Cr in exchangeable, carbonate, Fe-Mn oxide, and organic bound as well as residual fractions. The Pseudo total concentration of Cr had its average value of 19.85±7.94 mg kg^{-1} in pre-monsoon and in case of post-monsoon an average of 115.17±192.17 mg kg^{-1}. Sequential extraction was performed to evaluate the bioavailable fraction. Cr was mostly associated with residual phase (F5). Mean mobility factor (MF) for Cr in playground soil of Khagra was only 5.02 %. Geo-chemical indices such as Enrichment factor (EF), Geo-accumulation index (I_{geo}) and Contamination factor (CF), Ecological risk (ER) indicated very low pollution levels. Bioaccessible-Cr was most significantly correlated ($R^2 \geq 0.85$) in pre-monsoon and ($R^2 \geq 0.98$) post-monsoon indicated, when the total amount of Cr is increased leading to increase in bioaccessible fraction.

Keywords: Bioaccessibility, Chromium, Geo-accumulation index, Khagra city, Mobility factor, Playground, Risk assessment.

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INTRODUCTION

Rapid economic growth and surges in population primes to anthropogenic influences globally. Increase in population and their living standards in the urban areas deteriorate the environmental quality and most frequently urban soils, which were becoming very substantial with respects to human health (Patinha *et al.,* 2015). Potentially toxic elements (PTEs) like chromium are typically originated by anthropogenic influences viz., traffic emissions (vehicle exhaust particles, tyre and break lining wear particles, weathered street surface particles, big or small-scale industrial emissions and atmospheric deposits, urban soil has gained interest in research over the past few decades (Binggan and Linsheng, 2010; Karim and Qureshi, 2013; Lim *et al.,* 2013).

Urban soils have very impulsive soil structures, higher pH, low organic matter as well as high concentration of PTEs when equated to usual non-polluted soil (Bretzel and Calderisi, 2006).

Advancement of urban area together with both historical and industrial activities consequence to hostile effect on biota, which chiefs to bio-accumulation of those PTEs in plants and animals and inflowing into human food chain (Mir *et al.*,2020). Occurrence of contaminant in to the urban soil can projected to risk to human whether they exposed to acute or chronic and consequences into severe headache, nausea or vomiting, abdominal pain and diarrhea (Karim and Qureshi, 2013; Praveena *et al.*, 2015).

Urban playground appears to be a frivolous area for both children and adults. Due to these outdoor activities, this playground soil dust is potential to expose for children and adult both (Laha *et al.*, 2020). Fundamentally children ingest successive quantities of soil dust when playing on the ground and their propensity to hand to mouth activities (Pica behavior) and unfortunate ingestion of foodstuff when it was dropped onto the ground. Adult are not the least. They were also noteworthy to ingest soil dust which are adhere to foodstuff, cigarette and also through their hand sporadically. Therefore it is crucial to pay attention on exposure of Chromium through ingestion in different playground soils of Khagra.

The present study was therefore conducted to explore the 16 samples of Cr contaminated soil that accrued on top soil of outdoor playground in urban areas of Khagra. The objectives of this study were to: i) measure total and bio available Cr using sequential extraction, ii) determine contamination status of Cr using different pollution indices, iii) assess Cr-bioaccessibility through *in-vitro* digestion model and iv) to assess human health risk assessment of PTEs in playground soil dust. Thus, current study may help to improve methodology to envisage non-carcinogenic and carcinogenic health risks to adults and children associated with exposure of Cr-contaminated soils.

MATERIALS AND METHODS

Study area, sampling and sample preparation

Khagra is well-known for its bell metal and brass utensils industry and major commercial towns since the medieval period have a traditional demand in local markets and some are also exported. No machinery is used to make the different types of utensils, that's why Khagra is a cottage industry, where 100% of the work is handmade. Besides metal industries, ferries, tourist spots, highways are also present in the study area. Khagra is situated on the East bank of the Bhagirathi-Hooghly River and also neighborhood of Berhampore in Murshidabad (Fig. 1) district. This small-scale industrial area is frequently flooded during heavy rain by the river Bhagirathi, a tributary of river Ganga.

Top playground soil samples (0-20 cm) were collected through stainless steel corer from sixteen locations at Khagra (Fig. 1) during pre-monsoon season (February, 2014) and post-monsoon season (October, 2014). A total forty-eight number of top playgrounds soil samples (three sub samples from each playground) were collected from different playgrounds within the city of Khagra, Berhampore. Three randomly collected samples from each playground were homogenized and made a composite sample. After collection of samples, soils were dried in a hot air oven at <40°C.

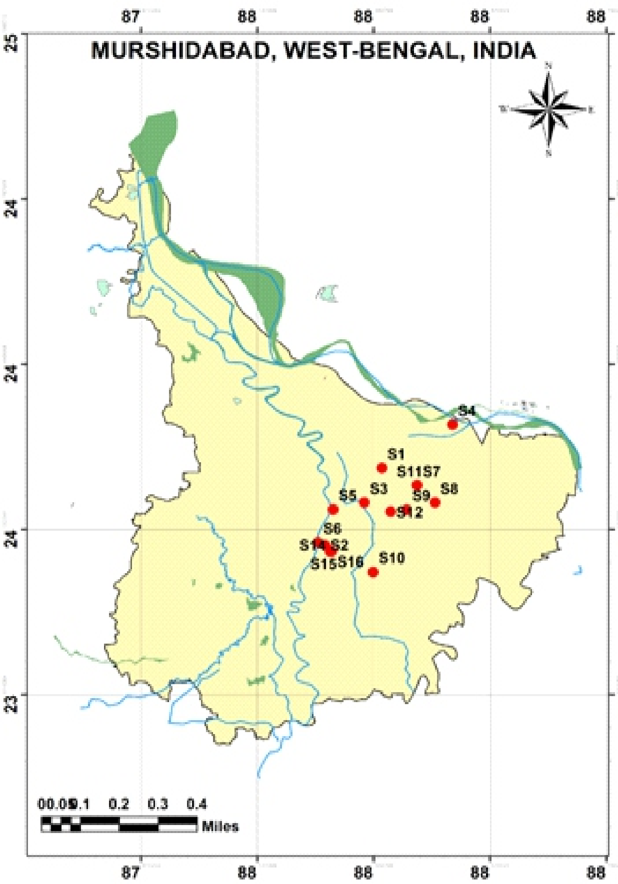

Fig. 1: Study area of Khagra, West Bengal.

Quality assurance

All of the glass apparatus used were soaked overnight in 20% of HNO_3 and washed thoroughly with deionized water to avoid contamination. Yttrium was added to all the solutions as an internal standard. All chemicals used were of analytical-grade and was purchased from Merck (India) and Sis Co Research Laboratories (India). Soil samples were extracted in triplicate. A blank was prepared along with samples to check for background levels of PTEs in the reagents used for various leaching procedures. For recovery analysis, one-gram soil sample was put into a Teflon digester and spiked with standard solution containing As, Cd, Co, Cu, Fe, Mn, Ni, Pb, Zn and Sn digested with 5:2:3 HNO_3, $HClO_4$ and HF mixture. After digestion, the sample was filtered and the volume was made up to 25 ml with 12 (N) HCl. The results obtained were compared with those of the un-spiked dust samples. The recovery of these spiked samples were 90% for As, 89% for Cd, 87% for Co, 91% for Cr, 92% for Cu; 91% for Fe, 90% for Mn, 89% for Ni, 94% for Pb, 91% for Zn and 87% for Sn.

Sequential extraction

Digestion and extraction for total PTEs did not provide adequate information about the degree of pollution and bioavailability of those PTEs to biota. Sequential extraction was incorporated to quantify the metal fractions, which could be accompanied with chemical species, as well as to potentially mobile, bioavailable or eco-toxic phases of a sample (Jena *et al.,* 2013). The sequential extraction (Tessier *et al.,* 1979) was provided to screen Cr in the playground soil into five fractions: exchangeable (F1), bound to carbonate phase (F2), bound to Fe-Mn oxides (F3), bound to organic matter (F4), and residual (F5). Sequential extraction was accomplished to administrate the kinesis of potentially mobile fractions of the Cr to playground soil samples. The sequential extraction process comprises treatment of a soil sample with a sequence of reagents having a different chemical property in order to partition the PTEs (Rao *et al.,* 2008).

Assessment of contamination and ecological risks

Assessment of contamination was accomplished with the calculation of enrichment factor, geo-accumulation index, contamination factor and ecological risk.

Enrichment factor (EF)

$$EF = \frac{C_i / C_{ref} \; of \; Sample}{B_i / B_{ref} \; of \; background} \qquad (1)$$

The EF for each element was used to estimate the anthropogenic impact of PTEs using the previously suggested formula by Kim and Kim (1999), Zhuang and Gao (2014) and Mohammad *et al.* (2015). Where C_i is the concentration of samples; B_i is the concentration of the background, respectively, while C_{ref} and B_{ref} are

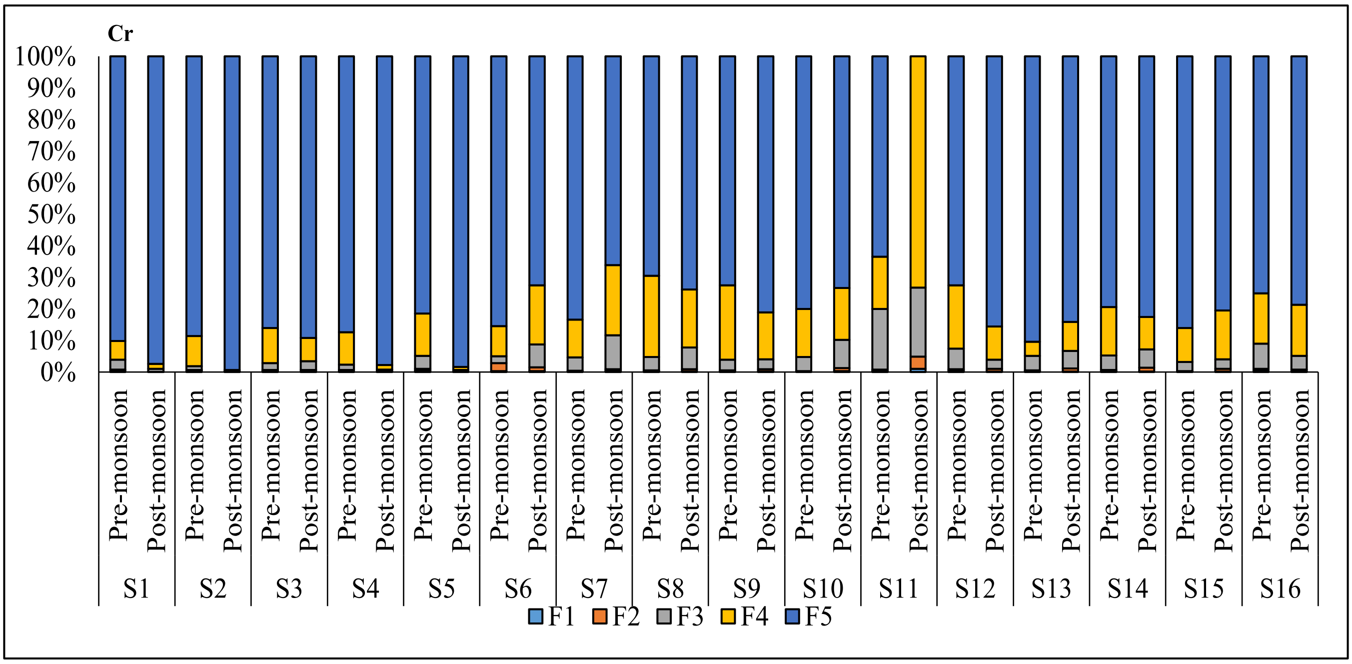

Fig. 2: Distribution of Cr fractions (%) at each sampling with seasonal variation.

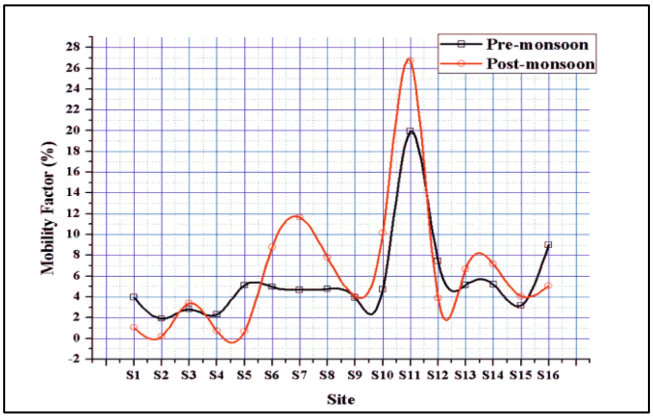

Fig. 3: Mobility factor (%) of Cr in playground soils in both seasons.

provided to standardize the PTEs. The crustal concentration of chromium is used in this study replaced by soil background value that removes the effects of natural geochemical variability (Zhang *et al.*, 2012).

Geo-accumulation index

$$I_{geo} = \log_2(C_i \,/\, 1.5 \times B_{ref}) \quad (2)$$

Where *Ci* is the dignified concentration of element in soil sample and B_{ref} is the natural background concentration of that element. The index of geo-accumulation index (I_{geo}) was used to measure the concentration of metal (Bai *et al.*, 2009) respect to background value. The factor of 1.5 is a background matrix correction factor that includes possible variations of the background values due to lithogenic effects.

Contamination factor

A contamination factor (C^i_f) to describe the contamination of a given toxic substance in a lake or a sub-basin suggested by Hakanson (1980) is

$$C_f^i = \frac{C_i}{C_{ref}} \quad (3)$$

According to Cabrera *et al.* (1999), *Ci* is the content of metal '*i*' instead of mean content from at least 5 sample sites; C_{ref} is the reference value or baseline level value. The level of contamination according to their value (Tomlinson *et al.*, 1980; Mohiuddin *et al.*, 2010) such as, C^i_f<1 represents low contamination, 1 ≤C^i_f< 3 as moderate contamination, 3 ≤C^i_f≤ 6 as considerable contamination and C^i_f> 6 as very high contamination respectively.

Ecological risk factor

An ecological risk factor (Er^i) to quantitatively express the potential ecological risk of a given contaminant also suggested by Hakanson (1980) is

$$Er^i = Tr^i . C_f^i \quad (4)$$

Where Tr^i is the toxic-response factor for a given substance, and C^i_f is the contamination factor. The following terminologies are used to describe the risk factor: Er^i<40, low potential ecological risk; 40≤ Er^i<80, moderate potential ecological risk; 80≤ Er^i<160, considerable potential ecological risk; 160≤ Er^i<320, high potential

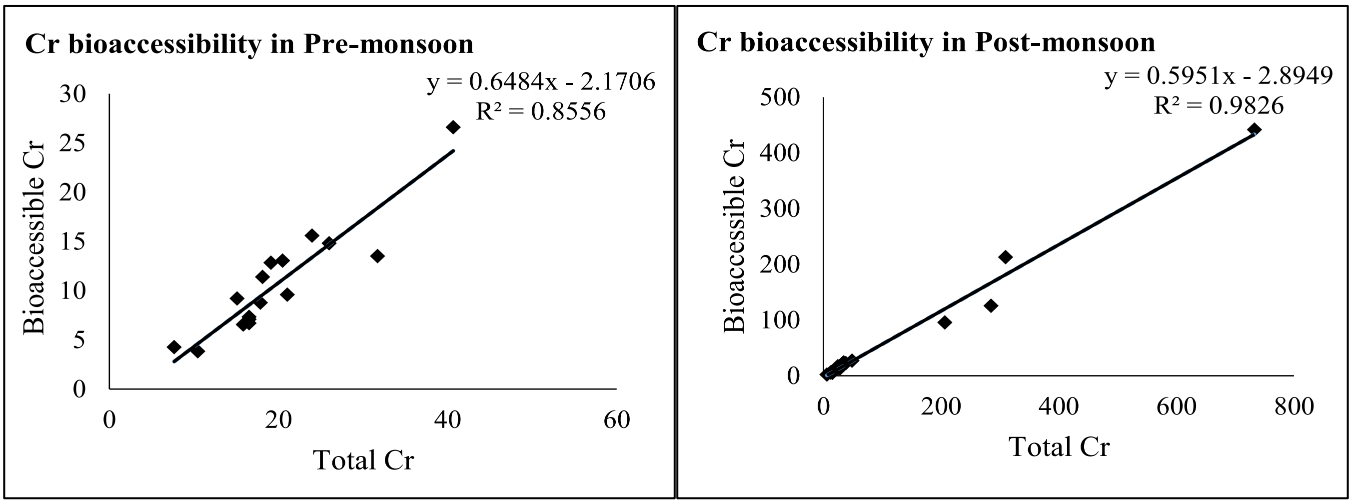

Fig. 4: Relationships between bioaccessible and total concentrations of Cr (mg kg^{-1}) in playground soils in both seasons.

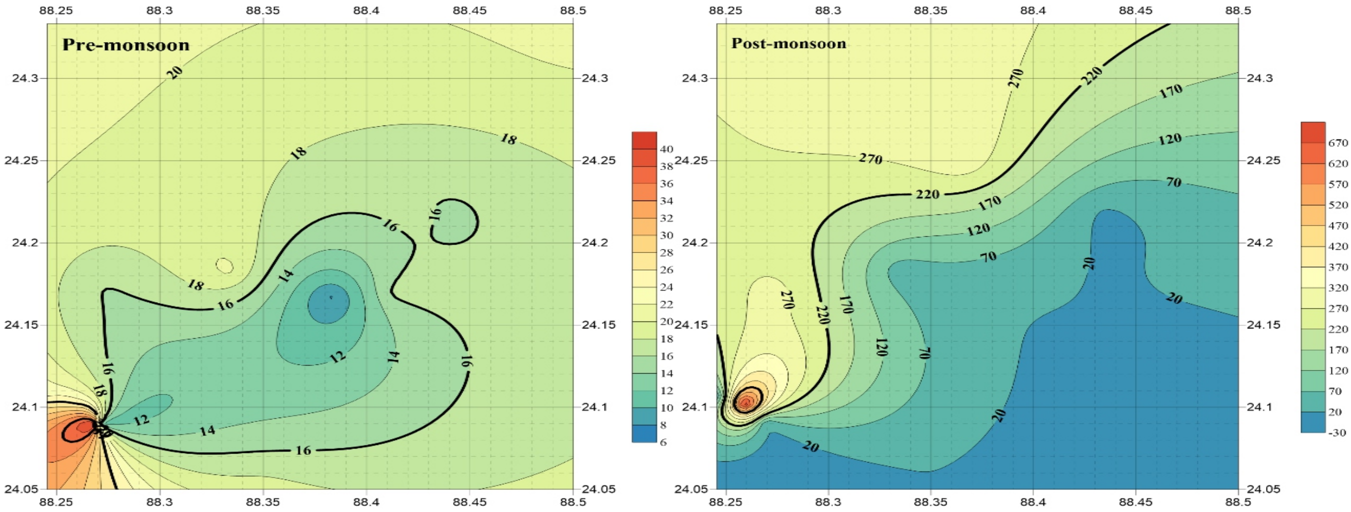

Fig. 5: Spatial distribution of Chromium in both season in playground soil of Khagra.

ecological risk; and $Er^i \geq 320$, very high ecological risk.

Mobility factor (MF)

The mobility factor (MF), for Pb in soil was determined by using the following equation (Narwal and Singh, 1998):

$$MF = \frac{(F1+F2+F3)}{\sum F} \times 100 \quad (5)$$

Here F1, F2, F3, F4 and F5 are the concentration of elements in exchangeable, carbonates, Fe-Mn oxides, organic matter and residual fractions respectively.

Simple bioavailability extraction test (SBET)

In this present study in vitro simple bioaccessibility extraction test (SBET) was incorporated to assess bioaccessible Cr (Oomen *et al.*, 2002) and analyzed by ICP-OES. Synthetic stomach fluid was prepared by dissolving glycine in de-ionized water and adjusting to pH 1.5 mimicking the gastric solution in human stomach. Each sample bottle was submerged in a water bath at 37°C to simulate human body temperature.

After completing the extraction process aliquot was directly taken from each reaction bottle, and passed through a 0.45 µm cellulose acetate disk filter. If the pH of leached sample fluid was not within ± 0.5 of the starting pH, the test was rejected and repeated again from first step. All sample aliquots were analyzed for Cr by Thermo Scientific ICP-OES Model: iCAP 6000 series. All analytical data were assessed for accuracy and precision using a quality control system during the analytical procedure according to Ramsey *et al.* (1987).

Bioaccessibility calculation

The bioaccessibility (BA) was calculated as a percentage of the total Cr content and amount of Cr present in the gastric phase using following equation,

$$BA\ (\%) = \frac{\text{Cr content (mg/kg) determined in gastric phase}}{\text{Total Cr content (mg/kg) in environmental media}} \quad (6)$$

Human health risk assessment

Possible health risk assessment of playground soil is comprehensively used to evaluate non-carcinogenic threats to human via three exposure pathways i.e., ingestion, inhalation and dermal contact. This approach employed for the health risk assessment was established on the guidelines and Exposure Factors Handbook of US Environmental Protection Agency (USEPA 1989; 2011). Average daily intake (ADI) was calculated for (i) direct ingestion of soil particles (ADI_{ing}); (ii) inhalation of re-suspended particles (ADI_{inh}); and (iii) absorption of PTEs from skin adhered dust particles (ADI_{dermal}). The equation for calculation of ADI is given below (Chen *et al.*, 2015; Laha *et al.*, 2020).

$$ADI_{ing} = A_m \times \frac{R_{ing} \times F_{exp} \times T_{exp}}{ABW \times T_{avg}} \times 10^{-6} \quad (7)$$

$$ADI_{inh} = A_m \times \frac{R_{inh} \times F_{exp} \times T_{exp}}{PEF \times ABW \times T_{avg}} \quad \textbf{(8)}$$

$$ADI_{dermal} = A_m \times \frac{SAF \times DAF \times A_{skin} \times F_{exp} \times T_{exp}}{ABW \times T_{avg}} \times 10^{-6} \quad \textbf{(9)}$$

Where ADI_{ing}, is the average daily intake (mg kg^{-1} day^{-1}) through ingestion. Exposure factors (in equation) and values used to estimate are given in Table 1. In this present study, non-carcinogenic health effects of PTEs were evaluated using the hazard quotient (HQ), hazard index (HI) through following equation (Eq. 10),

$$HI = \sum HQ = \sum \frac{ADI}{RfD} \quad \textbf{(10)}$$

The HQ is the ratio of the ADI_{ing}, of PTEs to its reference dose (RfD) for the same exposure pathway(s) (USEPA, 2011). The reference dose (RfD) (mg kg^{-1} day^{-1}) is the maximum daily dose of a PTE from a specific exposure pathway, for both children and adults, that is assumed not to lead to a considerable risk of toxic effects to sensitive individuals throughout lifetime (Thornton, 1991; Qing *et al.*, 2015). The hazard index (HI) is the sum of hazard quotient (HQ) and depicted of the total risk of non-carcinogenic PTEs through exposure pathways for single PTE. If the value of HI<1, no risk of non-carcinogenic effects is supposed to happen, whereas HI>1 specified a possibility of adverse health effects, and likelihood to increase with the increase of HI values (USEPA, 1989, 2011; Kumar *et al.*, 2014; Qing *et al.*, 2015).

The carcinogenic risk (CR) is considered by summing the individual cancer risk of all route of exposure using the following equation (Chen *et al.*, 2015):

$$CR = \sum CDI_{expr} \times CSF \quad \textbf{(11)}$$

Where expr = different exposure route i.e., ingestion, inhalation or dermal contact; CSF is carcinogenic slope factor. Carcinogenic slope factor is obtainable only for inhalation exposure route. So in the present study, carcinogenic risk has been evaluated from exposure to inhalation route only. Carcinogenic risks surpassing 1×10^{-4} are considered as objectionable, whereas risks beneath 1×10^{-6} are deliberated to pose no substantial health effects, and risks lying between the ranges of 10^{-6} to 10^{-4} considered as chance of occurrence of carcinogenic health effect (Chen *et al.*, 2015).

RESULTS AND DISCUSSION

Cr content in playground soil

The total concentration of Chromium was varying from 7.67 to 40.67 mg kg^{-1} with the average value of 19.85±7.94 mg kg^{-1} in pre-monsoon and incase of post-monsoon Cr ranged from6.22 to 732.70 mg kg^{-1} with an average of 115.17±192.17 mg kg^{-1} in playground soil samples, which was listed in Table 2. In the study area, the variation of Cr level was detected due to atmospheric deposition from small scale industries like dye, metal industries (bell metal and brass metal), combustion of coal and oil, civil works, incineration of municipal waste and fugitive emissions from road dusts (Environment Agency, 2002), which can be found in this study area. The fractionation of chromium designated that in most of the sites, major portion of chromium is attached with the residual fraction (F5) in both season (Fig. 2). In pre-monsoon season and post-monsoon season only site S11 contributed most of the Cr in organic and Fe-Mn oxide fraction. Though in post-monsoon season Cr was absent in residual fraction. Besides S11 all sites had immobile Cr in its strata. In pre-monsoon season very few percentage of Cr was bound to carbonate fraction in Site S6. In post-monsoon season significant quantity of chromium was found very less mobile (5%) having 1.5% of bioavailability. The mean Cr content (in percentage) was found in order of F5 (80.71 %) > F4 (13.72 %) > F3 (4.78 %) > F2 (0.45 %) > F1 (0.34 %) and F5 (78.8 %) > F4 (14.8 %) > F3 (5.3 %) > F2 (0.8 %) > F1 (0.2 %) in pre-monsoon and post-monsoon respectively. Imperato *et al.* (2003) also found that the Cr was prevalent in residual pool, indicating limited relatively mobility. In post-monsoon season average mobility (%) (Fig. 3) was greater than pre-monsoon at site S11 and S7 followed by S14.

The spatial distributions of Chromium in the study area were shown in Fig. 5. The spatial distributions of Cr in the contour maps were a little similar in both season: the most serious

Table 1: Definition and reference value of some parameters for health risk assessment of PTEs in urban soils.

Exposure factors	Adult	Child	Reference
Ingestion rate (mg day^{-1}) [R_{ing}]	100	200	(USEPA, 2011)
Inhalation rate (m^3 day^{-1}) [R_{inh}]	20	7.6	(USEPA, 2011)
Exposure frequency (days year^{-1}) [F_{exp}]	365	365	(Kumar *et al.* 2014)
Exposure duration, ED (year) [T_{exp}]	24	6	(USEPA, 2011)
Body weight (kg) [ABW]	60	18	(ICMR, 2009)
Particulate emission factor (m^3 kg^{-1}) [PEF]	1.36 x 10^9	1.36 x 10^9	(USEPA, 2011)
Skin area (cm^2) [A_{skin}]	5700	2800	(USEPA, 2011)
Dermal absorption factor (unitless) [DAF]	0.001	0.001	(Kumar *et al.*, 2014)
Skin adherence factor (mg cm^{-2} h^{-1}) [SAF]	0.07	0.2	(USEPA, 2011)
Averaging time for non-carcinogens (days) [T_{avg}]	8760	2190	(Laha *et al.*, 2020)
Carcinogenicity slope factor (mg kg^{-1} day^{-1}) [SF]	Inhale [Cr : 42]		(Chen *et al.*, 2015)

Table 2 : Seasonal variation of total and bioaccessible Cr in playground soil.

	Pre-monsoon			Post-monsoon		
Site	**Total Cr (mg kg^{-1})**	**Bioaccessible Cr (mg k^{-1})**	**Bioaccessibility (%)**	**Total Cr (mg k^{-1})**	**Bioaccessible Cr (mg k^{-1})**	**Bioaccessibility (%)**
S1	17.86	8.80	49.28	309.88	212.95	68.72
S2	26.01	14.80	56.90	732.70	441.70	60.28
S3	20.49	13.05	63.70	48.72	27.30	56.03
S4	21.03	9.60	45.64	206.12	95.40	46.28
S5	15.83	6.55	41.37	285.05	125.55	44.04
S6	23.95	15.60	65.14	15.51	5.60	36.10
S7	16.54	7.10	42.92	12.45	5.90	47.38
S8	16.54	7.35	44.45	28.54	13.15	46.07
S9	16.52	6.70	40.56	24.76	13.70	55.32
S10	19.09	12.85	67.32	14.01	6.70	47.82
S11	15.11	9.20	60.90	6.22	2.05	32.94
S12	7.67	4.25	55.41	29.14	14.55	49.93
S13	40.67	26.60	65.40	34.47	23.95	69.48
S14	18.11	11.40	62.96	38.04	22.65	59.54
S15	31.71	13.50	42.57	24.55	16.90	68.83
S16	10.47	3.85	36.77	32.60	22.30	68.41
Min	7.67	3.85	36.77	6.22	2.05	32.94
Max	40.67	26.60	67.32	732.70	441.70	69.48
Mean	19.85	10.70	52.58	115.17	65.65	53.57
St. Dev	7.94	5.57	10.66	192.17	115.37	11.66

pollution was found in Site S2 and S1 followed by S4 and S5 out of 16 playgrounds in study area, which indicated that it may be a same pollution source from vehicular as well as non-vehicular

Table 3: Different geo-accumulation indices of Cr in playground soil of Khagra.

	Pre-monsoon				Post-monsoon			
Site	I_{geo}	**CF**	**EF**	**ER**	I_{geo}	**CF**	**EF**	**ER**
S1	-3.07	0.18	0.92	0.36	1.05	3.10	13.29	6.20
S2	-2.53	0.26	1.11	0.52	2.29	7.33	53.21	14.65
S3	-2.87	0.20	0.78	0.41	-1.62	0.49	1.81	0.97
S4	-2.83	0.21	1.15	0.42	0.46	2.06	9.24	4.12
S5	-3.24	0.16	0.78	0.32	0.93	2.85	12.69	5.70
S6	-2.65	0.24	1.27	0.48	-3.27	0.16	0.92	0.31
S7	-3.18	0.17	0.86	0.33	-3.59	0.12	0.70	0.25
S8	-3.18	0.17	0.73	0.33	-2.39	0.29	1.54	0.57
S9	-3.18	0.17	0.89	0.33	-2.60	0.25	1.22	0.50
S10	-2.97	0.19	0.79	0.38	-3.42	0.14	0.74	0.28
S11	-3.31	0.15	0.88	0.30	-4.59	0.06	1.05	0.12
S12	-4.29	0.08	0.43	0.15	-2.36	0.29	1.18	0.58
S13	-1.88	0.41	1.81	0.81	-2.12	0.34	1.30	0.69
S14	-3.05	0.18	0.74	0.36	-1.98	0.38	1.50	0.76
S15	-2.24	0.32	1.41	0.63	-2.61	0.25	1.22	0.49
S16	-3.84	0.10	0.48	0.21	-2.20	0.33	1.27	0.65

Table 4 : Health risk assessment of Cr in playground soils of Khagra.

Element	**Reference Dose (RfD)**			**Target**	**Hazard Quotient (HQ)**				
	Ingestion	**Inhalation**	**Dermal**		**Ingestion**	**Inhalation**	**Dermal**	**HI= ∑HQ**	**Carcino-genic risk**
Cr (Premonsoon)	3.00E-03	2.80E-05	7.50E-05	Child	7.35E-02	2.20E-04	8.23E-03	0.082	9.29E-03
				Adult	1.10E-02	1.74E-04	1.76E-03	0.013	1.40E-03
Cr (Postmonsoon)	3.00E-03	2.80E-05	7.50E-05	Child	4.27E-01	1.28E-03	4.78E-02	0.476	5.39E-02
				Adult	6.40E-02	1.01E-03	1.02E-02	0.075	8.10E-03

exhaust and also associated with industrial activities which were mainly scattered throughout the study area (Xu *et al*., 2016).

Oral bioaccessibility of Cr in playground soil

The result of in vitro bioaccessibility test is given in the Table 2. The acquired result specified good linear relations among bioaccessibility values and total Cr concentrations (Fig. 4). Cr was ominously correlated ($R^2 \geq 0.85$) in pre-monsoon and ($R^2 \geq 0.98$) indicated the total amount increased leading to increased bioaccessible fraction. Moreover, they also indicated that anthropogenically influence of Cr was more commonly accompanying with bio-available phases. The average oral bioaccessibility of Cr from playground soil samples were, 10.70±5.57 mg kg^{-1} in pre-monsoon and in post-monsoon the level was 65.65±115.37 mg kg^{-1} in gastric juice. In post-monsoon the concentration of Cr is approximately ten times higher than the pre-monsoon season because the sampling areas were frequently flooded during the monsoon and surface runoff may deposit most of the Cr rich sediment to the low land playground. When surveying through local people and industrial person it was found that during post-monsoon the work load was maximum because maximum festival (fair/ mela) taken place during this season. On the other hand we can see that the in post-monsoon season the bioaccessible Cr most significantly correlated with the total concentration found in the playground soil.

Assessment of the heavy metal contamination

In this present study, the I_{geo}, contamination factor

(CF), enrichment factor (EF), and ecological risk factor (ER) were introduced to evaluate the degree of Cr pollution in playground soil. The designed I_{geo} values of Cr in playground soils are presented in Table 3. The I_{geo} value for Cr was ranged from -4.29 to -1.88. S13 playground soil falls on class 0 category which indicated that the soil of S13 playground soil was practically uncontaminated with Cr. The main cause of degree of contamination of Cr in playground soil was dispersion and runoff through water from nearby different small scale industry bell metal, dye, non-vehicular exhaust.

CF was applied to find out the levels of Cr in topsoil samples. CF for topsoil of playground clearly indicated the role played by dry deposition as well as surface runoff. According to Table 3, CF for Cr showed low contamination in the entire playground. Cr was deposited through atmospheric deposition, wind action or surface runoff.

The Enrichment factor (Table 3), basically designed as per earth crust standardization, originate that soils of the area were enriched with Cr. Enrichment factor >1.5 was deliberated indicative of human influence with that particular PTEs. Except for a few sites during the post-monsoon season, Cr revealed minimal enrichment in all considered playground soil, indicating human intervention.

Ecological risk (ER) recommended the sensitivity of biota to PTEs and determined the probable potential ecological risk generated by Cr (Li *et al*., 2014; Islam *et al*., 2015). The ER index for PTEs identified that the area had low potential ecological risk.

Health risk assessment

The calculated risk for children as well as adult in urban playground of the study area fall below the threshold of unacceptability (HI=1), but it has an important involvement to the overall risk from exposure to Cr experienced by those receptors in urban environments. Considering sensitive population groups and land use types, the predicted daily exposure, non-carcinogenic risks (HQ), and carcinogenic risk chromium depicted in Table 4.

CONCLUSION

In this present study, sixteen soil samples from urban playground throughout Khagra, Murshidabad were collected and soil pollution through Chromium and its health risk assessments were evaluated. Chromium concentration found to be lower than the international limit suggests necessity for remediation of polluted site post-monsoon. Distribution of Chromium in playground soil trailed the pattern of urban sprawl. Though sequential extraction of Cr recommends less mobility due to dominant residual pool, an increment in industrial activities, urbanization and vehicular exhaust automatically influence chromium deposition on understudied area. Carcinogenic risk (inhalation) for both children and adult is found to be objectionable in study area whereas non-carcinogenic risk (HI<1) on children's health shows that level of exposure may lead to potential hazard in near future due to pica behavior and dermal adsorption.

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