

Trace Elemental Characterization of Chalk Dust and Their Associated Health Risk Assessment

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Abstract It is evident that chalk produces dust on use, i.e., particulate matter, which will alter the air quality of classrooms and can cause health hazards in teachers. The possible causes for health effects of chalk dust on teachers are still unclear. Hence, the aim of this study is to estimate the concentration of trace elements (Al, Cr, Mn, Fe, Co, Ni, Si, Pb) in chalk dust collected from classrooms by using ICP-MS. Both suspended and settled chalk dust was collected from selected classrooms. Suspended chalk dust was collected with PM2.5 filter paper using fine dust sampler, and settled chalk dust was collected by placing petriplates at a distance of 3 m from the board for a duration period of 30 min. Scanning electron microscopy images of chalk dust were taken up. Potential health risk analysis was also assessed. Results showed that Al, Fe, and Mn are in higher concentration ($>1000 \mu\text{g kg}^{-1}$) in both settled and suspended chalk dust. Cr, Mn, Fe, Co, and Ni were beyond the minimal risk levels in both settled and suspended chalk dust. There are no minimal risk levels for the elements Al, Si, and Pb. The concentration of trace elements in suspended chalk dust was higher than that in settled chalk dust. The SEM images of PM2.5 filter papers (suspended chalk dust) showed that all pores of the sampled filter papers are clogged with chalk dust. The few SEM images of the settled chalk dust showed fibrous shape which is associated with good-quality chalk whereas others showed circular and more aggregated nature of chalk dust from low-quality chalk

from which the dust production will be very high. As observed from the result that the trace elements concentration was high in the suspended chalk dust, the fact can be correlated with the SEM images which have shown high density of absorbed chalk dust. With reference to human health risk, dermal exposure was the main route of exposure followed by inhalation and ingestion. Al (aluminum), Fe (iron), Si (silicon), and Mn (manganese) are the major contributors for the non-carcinogenic effects. For all the elements, the carcinogenic effect calculated (LADD) is within the global acceptable limit (10^{-6} – 10^{-4}).

Keywords Chalk dust · Trace elements · Health risk

The concept of black board teaching is the ancient and economical method of teaching which is practiced in many parts of India [1]. The usage of chalk sticks can cause health hazards [2]. The chalk sticks while scrapping on black board release dust particles that pose health hazards to teachers [3]. In this modern era, several new methods of teaching like marker boards, digital boards, and power point presentations were introduced. Only few schools are accommodating these modern methods of teaching due to higher running costs [4].

Chalk composes of CaCO_3 , $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, additives like CMC (carboxyl methyl cellulose), PVA (poly vinyl alcohol), and starch which were used as thickeners, and water binders ZnO , kaolinite, and colored pigments with standard grain size of these particles. The quality of chalk depends on the percentage of CaCO_3 and its controlling variables like binders. Chalks with less than 6 % of CMC are dusty [5].

Initially, chalk was known to be dusted chalks composed of calcium sulfate (gypsum). The dust particles released from these chalks tend to remain in air for longer period of time. Later on, many industries launched dustless chalks. These

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dustless chalks are made up of calcium carbonate with the binder in the chalk that releases dust with large particles which are not respirable and settle faster [6].

Good quality and dustless chalks are usually imported from Europe, China, Taiwan, or the USA. Chalks that are manufactured in Jordan, United Arab Emirates, Japan, and China consist mainly of gypsum where as the chalks from Holland, France, the USA, and England are composed of a mixture of calcite and gypsum [5].

Particle size distribution and morphological studies of chalk revealed that both dusted and dustless chalks produce aerodynamic dust particle size of <PM 11 to <PM 2 which could be potentially dangerous to human health [7]. The inhalation of this particulate matter can pose respiratory problems [8, 9]. The chalk dust particles that settle on the body parts of teachers and their clothes, and classroom benches cause allergic problems [10]. The usage of chalk causes the Eczema of the hand and also a patch test of chalk on teachers confirmed that chalk is an allergen [11].

To the best of our knowledge, very scanty information is available on chalk dust and its associated health impacts. Initially, the studies on the chalk were done to improve the quality of chalk [5]. After that, morphological studies were conducted to know the aerodynamic size of dust particles generated from the chalk dust [7]. Later, the few studies noticed that the chalk dust particles can alter the indoor air quality [12] and also, few occupational studies noticed that chalk dust is causing allergic dermatitis [13, 11]. In the present scenario, a recent study revealed that chalk dust may cause the oxidative damage to the alveolar macrophages [14]. On an average, 83 and 94 % (volume) of chalk dust is produced in classroom per unit time which is sufficient to various trace elements to cause carcinogenic and non-carcinogenic effects [7], and the major myth about chalk dust is that it is non-toxic and safe but few trace elements present in chalk may be harmful. So, it is felt desirable to know the characterization of elements in chalk dust. Thus, the objectives of the study are (1) characterization of trace elements from both the settled and suspended dust. (2) Image studies were performed using scanning electron microscopy (SEM) to know the morphology and adsorption the chalk dust. (3) Potential health risk assessment of adults (teachers) to these elements through various routes of exposure was investigated.

Materials and Methods

Sample Collection and Preparation

Suspended chalk dust particle was collected from selected classrooms by using fine dust sampler (Envirotech made, model no. APM550) and the sampler was run continuously for 8 h from morning to evening during working days [15].

The sampler was kept near to the board at a height of 1–2 m in the classroom at which the pupils would normally inhale. This was chosen as a typical location inside the room, it being away from the door, thus avoiding disturbances resulting from air currents [16].

The settled chalk dust samples were collected from the selected classrooms during teaching hours by placing petriplate near to the black board to a distance of 3 m for 30 min [7]. Samples were collected in triplicate, based on the standard method and owing to the fact that settlement is more between 0 and 3 m distance from the board.

Digestion Procedure

For Suspended Chalk Dust

Based on the reference studies, microwave digestion process was followed [17]. Filter papers were digested using hydrochloric and nitric acid mixture (3:1) by microwave digestive system (CEM) for 23 min at about 180 °C. The digested samples were filtered and stored in volumetric flasks.

For the Settled Chalk Dust

The known concentration of settled chalk dust samples were taken and digested by adopting standard digestion process with nitric-perchloric acid [18], and then the digested samples were analyzed further for trace element characterization.

Experimental Setup

The Agilent 7700s inductively coupled plasma mass-spectroscopy (ICP-MS) system (Agilent Technologies, Tokyo, Japan) was engaged to assess the ion profile. Platinum sample cone and skimmer cone were utilized with an orifice diameter of 1.0 to 0.4 mm, respectively. Sample introduction was performed with a micro mist nebulizer combined with Scott-type double-pass spray chamber (Agilent Technologies).

The instrument was tuned to optical conditions in terms of sensitivity (Li, Y, Co, and Ti) and Ce0/Ce and Ce2+/Ce by using a tuning solution (Agilent Technologies) containing 1 mg L⁻¹ of Li, Y, Ti, Ce, and Co in 2 % HNO₃ (W/V). The instrument was operated in full quantitative mode, and typical operating conditions used in this study are summarized in the Table 1.

Validation of ICP-MS

To validate the method, three randomly selected chalk samples were mixed together and spiked with known

Table 1 IC-PMS operating parameters

Parameter	Value
Plasma conditions	Forward power 1500 W
Plasma glass flow	15.0 L min ⁻¹
Carrier glass flow	0.75 L min ⁻¹
Dilution glass flow	1 L min ⁻¹
He gas flow	4–5 mL min ⁻¹
QP bias	–15v
Oct bias	–18v
Cell entrance	–40v
Cell exit	v60v
Deflect	–0.8v
Plate bias	–6.0v
Nebulizer type	Miramist
Sample uptake rate	1.5 mL min ⁻¹

concentrations. From the results, we have calculated percentage recoveries based on the following equation.

$$\text{Percentage recovery} = \left[C_E / C_M \times 100 \right]$$

where C_E is the experimental concentration determined from the calibration curve and C_M is the spiked concentration [19].

Elements Analyzed

Based on the reference studies, the elements like Al (aluminum), Cr (chromium), Mn (manganese), Fe (iron), Co (cobalt), Ni (nickel), Si (silicon), and Pb (lead) were analyzed in both settled and suspended chalk dust [15, 20].

Scanning Electron Microscopy

The collected samples were sent to the Nishka Laboratories, Hyderabad, for image studies.

Health Risk Assessment

Health risk assessments were performed by adopting the standard methods developed by the US Environmental Protection Agency [21–28]. The subjects considered in this study are only adults (teachers). Main routes of exposure to dust can occur in three pathways like ingestion, inhalation, and dermal contact. The exposure calculation for daily estimation was calculated by using the following equations.

Ingestion dose

$$D.\text{ing} = c \times \left(\frac{\text{ingR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}} \right) \times 10^6 \quad (1)$$

Inhalation dose

$$D.\text{inh} = c \times \left(\text{InhR} \times \text{EF} \times \text{ED} / \text{PEF} \times \text{BW} \times \text{AT} \right) \quad (2)$$

Dermal dose

$$D.\text{dermal} = c \times \left(\text{SL} \times \text{SA} \times \text{ABS} \times \text{EF} \times \text{ED} / \text{BW} \times \text{AT} \right) \times 10^6 \quad (3)$$

where D (mg kg⁻¹ day⁻¹) is the dose contacted through ingestion (D.ing), inhalation (D.inh), and dermal contact (D.dermal). Ingestion rate (IngR) is 100 mg day⁻¹ [29] for adults. Inhalation rate (InhR) is 20 m³ for adults [30]. Exposure frequency (EF) is 180 days year⁻¹ [24, 27]. Exposure duration (ED) is 24 years for adults [29]. Body weight (BW) is 70 kg for adult [21]. Average time (AT) for non-carcinogens is ED × 365 days; for carcinogens, 70 × 365 [26]. Particle emission factor (PEF) is 1.36 × 10⁹ m³ kg⁻¹, skin surface area (SA) is 3300 cm² for adults, skin adherence factor (SL) is 0.7 mg cm⁻² day⁻¹ for adult, and dermal absorption factor (ABS) is 0.03 for arsenic and 0.001 for Cd. No values were available for other elements; therefore, 1.0 % were used.

The assessment of cancer risk is done by calculating life time average daily dose (LADD) as a weighted average for each exposure pathway and is given in the following equation:

Life time average daily dose

$$\begin{aligned} \text{LADD} (\text{mg/kg/day}) &= C \times \frac{\text{EF}}{\text{AT}} \times \text{CRchild} \\ &\quad \times \text{EDchild} / \text{BWchild} \\ &\quad + \text{CRadult} \\ &\quad \times \text{EDadult} / \text{BWadult} \\ &\quad \times 10^{-6} \end{aligned} \quad (4)$$

where all the symbols denotes the same variables as above; however, the CR denotes the contact rate that is for ingestion (CR = IngR), for inhalation (CR = InhR), and for dermal absorption (CR = SA × SL × ABS).

The dose calculated for each element and for each exposure route is then divided by reference dose to get hazard quotient (HQ) that will be summed up for the three exposure pathways. The health risk was calculated using the following relation [31]:

$$\text{HQ} = \frac{D_i}{\text{Rfd}} \quad (5)$$

where D_i is the exposure path dose and Rfd is the threshold dose. The risk due to the cancerous effects is determined by multiplying the lifetime average daily dose (LADD) with

Table 2 Recovery of elements from the spiked chalk samples ($N = 10$)

Elements	Added ($\mu\text{g L}^{-1}$)	Measured mass fractions		% of recovery
		Obtained value($\mu\text{g L}^{-1}$)	Spiked value ($\mu\text{g L}^{-1}$)	
Al	1.0	19.6	20.3	70
Cr	1.0	0.80	1.75	95
Mn	10.0	16.06	25.2	91.4
Fe	10.0	397.6	408.2	110
Co	1.0	10.04	10.9	90
Ni	1.0	0.74	1.4	70
Si	10	2.42	3.12	70
Pb	10.0	1.73	9.1	73.7

corresponding slope factor of the exposure path and then the risk for each exposure path is summed up to get the overall cancer risk.

$$\text{Risk} = \text{LADD} \times \text{SF} \quad (6)$$

where SF is the slope factor of the exposure pathway.

Results and Discussion

Trace Elements Concentration

Due to lack of an appropriate certified commercial reference material of chalk, the recovery rate was measured using known spiked concentration of all investigated elements (Al, Cr, Mn, Fe, Co, Ni, Si, Pb). The consistency of the results was confirmed by measuring the recoveries of the spiked elements to the sample solutions. The percentage recovery of analyzed

trace elements ranged between 70 and 110 % (Table 2) indicating good accuracy, precision, and validity of method used [39]. Simultaneously each chalk sample (P = chalk dust collected in petriplate through settling technique; F = chalk dust collected on filter paper using fine dust sampler) was analyzed for eight elements and results are shown in Table 3. Previous studies show major elements in indoors of schools [32, 33]. Among all the elements Al (aluminum) was reported as an abundant element with a mean concentration ranging 3596.5 and 2177.6 $\mu\text{g kg}^{-1}$ in both settled and suspended chalk dust. Mn (manganese) and Fe (iron) was reported high when compared to other elements. The mean concentrations of Mn (manganese) and Fe (iron) are 801.8, 1061.8 $\mu\text{g kg}^{-1}$ and 334.8 and 516 $\mu\text{g kg}^{-1}$ in both settled and suspended chalk dust. The same was reported in the indoor dust samples of classrooms [33, 34].

As there are no standard guidelines for the trace elements in chalk and chalk dust, the obtained concentrations were compared with ATSDR (Agency for Toxic Substances and

Table 3 Trace elements concentration in chalk dust samples

Codes of chalk dust	Elements analyzed in chalk samples							
	Al	Cr	Mn	Fe	Co	Ni	Si	Pb
P-1 (settled)	3516.9 $\pm$ 7.5	154.3 $\pm$ 17.7	1715.9 $\pm$ 4.7	547.7 $\pm$ 1.3	588.8 $\pm$ 4.5	61.1 $\pm$ 1.1	233.7 $\pm$ 7.6	216.7 $\pm$ 4.6
P-2 (settled)	3162.2 $\pm$ 6.8	117.3 $\pm$ 11.5	1642 $\pm$ 4.3	326 $\pm$ 4.2	214.5 $\pm$ 3.6	11.7 $\pm$ 0.8	1153.8 $\pm$ 6.2	388.1 $\pm$ 5.2
P-3 (settled)	1973 $\pm$ 5.7	211.1 $\pm$ 7.9	512.4 $\pm$ 8.5	104.2 $\pm$ 0.3	15.7 $\pm$ 1.2	41.8 $\pm$ 1.4	633.5 $\pm$ 4.1	152.6 $\pm$ 4.8
P-4 (settled)	1055.4 $\pm$ 5.4	111.5 $\pm$ 12.8	86 $\pm$ 1.4	2.5 $\pm$ 0.7	44.3 $\pm$ 0.9	11.3 $\pm$ 0.6	138.7 $\pm$ 6.3	45 $\pm$ 2.2
P-5 (settled)	1180.9 $\pm$ 8.1	100 $\pm$ 3.1	52.8 $\pm$ 2.3	694 $\pm$ 9.3	255.4 $\pm$ 5.3	31.3 $\pm$ 1.2	421.5 $\pm$ 4.3	186.9 $\pm$ 1.8
F-1 (suspended)	1205.6 $\pm$ 6.2	313.3 $\pm$ 4.3	1438.3 $\pm$ 25.3	341.5 $\pm$ 5.2	526.3 $\pm$ 5.7	63.3 $\pm$ 0.4	480.4 $\pm$ 6.4	103.1 $\pm$ 1.3
F-2 (suspended)	1109.6 $\pm$ 7.5	215 $\pm$ 4.3	757.9 $\pm$ 12.2	140.8 $\pm$ 2.2	245.7 $\pm$ 1.3	54.5 $\pm$ 2.7	16.7 $\pm$ 6.1	94.2 $\pm$ 1.0
F-3 (suspended)	3251.2 $\pm$ 3.2	146.5 $\pm$ 17.1	848.6 $\pm$ 5.4	991.5 $\pm$ 1.7	132.9 $\pm$ 2.4	29.1 $\pm$ 0.7	374.9 $\pm$ 9.3	315.9 $\pm$ 5.3
F-4 (suspended)	5173.4 $\pm$ 9.7	291.4 $\pm$ 8.6	1271 $\pm$ 2.1	5.45 $\pm$ 0.5	25.45 $\pm$ 3.2	15.7 $\pm$ 0.9	381.4 $\pm$ 3.3	151.3 $\pm$ 0.7
F-5 (suspended)	7243.1 $\pm$ 7.3	186.3 $\pm$ 13.1	993.4 $\pm$ 1.2	1101 $\pm$ 6.7	139.5 $\pm$ 5.1	126.7 $\pm$ 1.0	549.8 $\pm$ 5.4	420.9 $\pm$ 3.5

The concentrations were measured in micrograms per kilogram

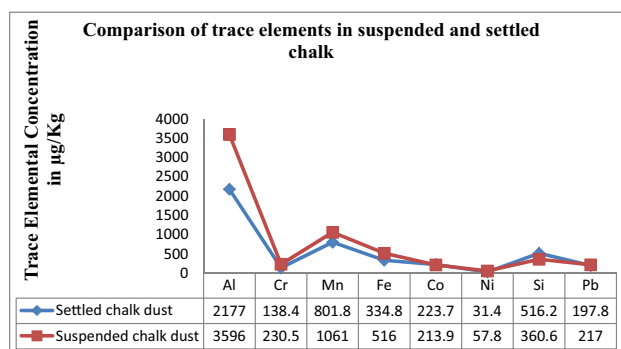
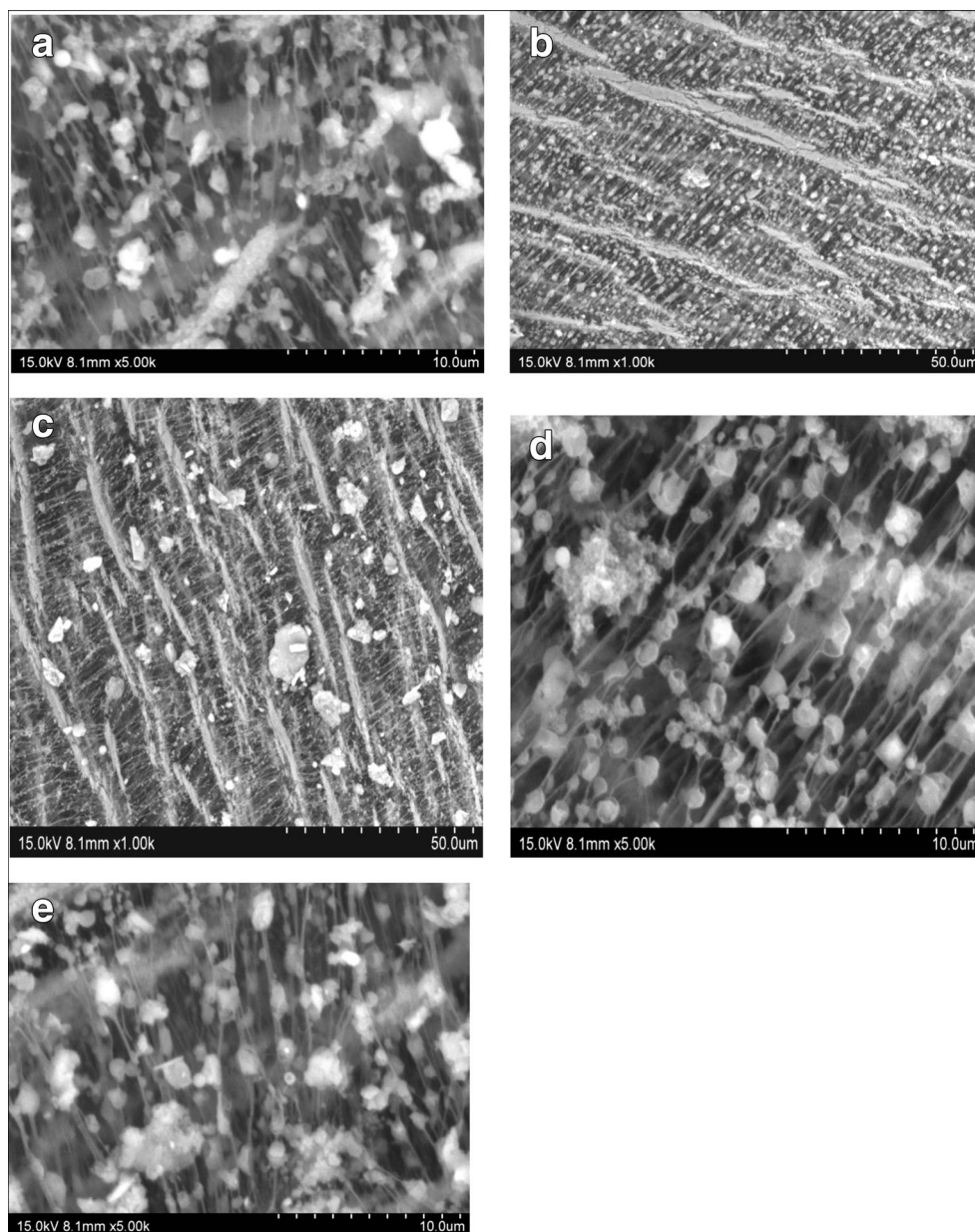


Fig. 1 Comparison of the trace elements (averages) of settled and suspended chalk dust samples

Disease Registry) minimum risk levels [40]. The obtained concentrations of the elements Cr (chromium), Mn (manganese), Fe (iron), Co (cobalt), and Ni (nickel) were beyond the minimal risk levels in both settled and suspended chalk dust. The minimal risk levels for the elements Cr ($0.0005 \text{ mg kg}^{-1}$), Mn (0.3 mg kg^{-1}), Fe (5 mg kg^{-1}), Co ($0.0001 \text{ mg kg}^{-1}$), and Ni ($0.0002 \text{ mg kg}^{-1}$). There is no minimal risk levels for the elements Al (aluminum), Si (silicon), and Pb (lead). The trace element concentration was noticed high in suspended chalk dust than settled chalk dust (Fig. 1). Majority of school teachers are still using dusted chalks due to economic viability [6, 7]. Dusted chalk dust tends to remain in the air in suspended state than dustless chalk.

Fig. 2 Scanning microscopic images of suspended chalk dust particles



In Fig. 2, the SEM images of filter papers a to e depict that the adsorption of chalk dust on the pm2.5 filter paper is so high. All the pores of the filter paper are clogged with chalk dust. All the images showed elongated nature of chalk dust. Images a to e in Fig. 3 depict chalk dust of fibrous shape which is associated with good-quality chalk, i.e., non-dust [6], whereas image E shows circular but more aggregated nature of chalk dust from low-quality chalk from which the dust production will be very high. The trace elements concentration was high in the suspended chalk dust; the fact can be correlated with the SEM images which have shown high density of absorbed chalk dust.

Health Risk Assessment to Adults

The doses thus calculated for each element and exposure pathway are subsequently divided by the corresponding reference dose to yield a hazard quotient (HQ) (or non-cancer risk),

whereas for carcinogens, the dose is multiplied by the corresponding slope factor to produce a level of cancer risk. The toxicity values used in the analysis were given by the US Department of Energy [35], and for the element Pb, the reference value was taken from the WHO (World Health Organization) [36] guidelines for drinking water quality. The slope factor, i.e., inhalation slope factor, is only available for the elements Cr, Co, and Ni. So the cancer risk was calculated for Cr, Co, and Ni using inhalation slope factor. The exposure doses of elements in chalk dust are listed in the Table 4. The dermal contact of chalk dust appears to be the major route of exposure to the teachers. This route is followed by inhalation and ingestion of chalk dust. Previous studies widely reported that allergic dermatitis and respiratory diseases are more prevalent in teachers [37, 11]. This fact is correlated with exposure routes of the present study. In terms of total exposure, the non-carcinogenic elements like Al (aluminum), Fe (iron), Si (silicon), and Mn (manganese) and carcinogenic elements [38]

Fig. 3 Scanning electron microscopy images of settled chalk dust

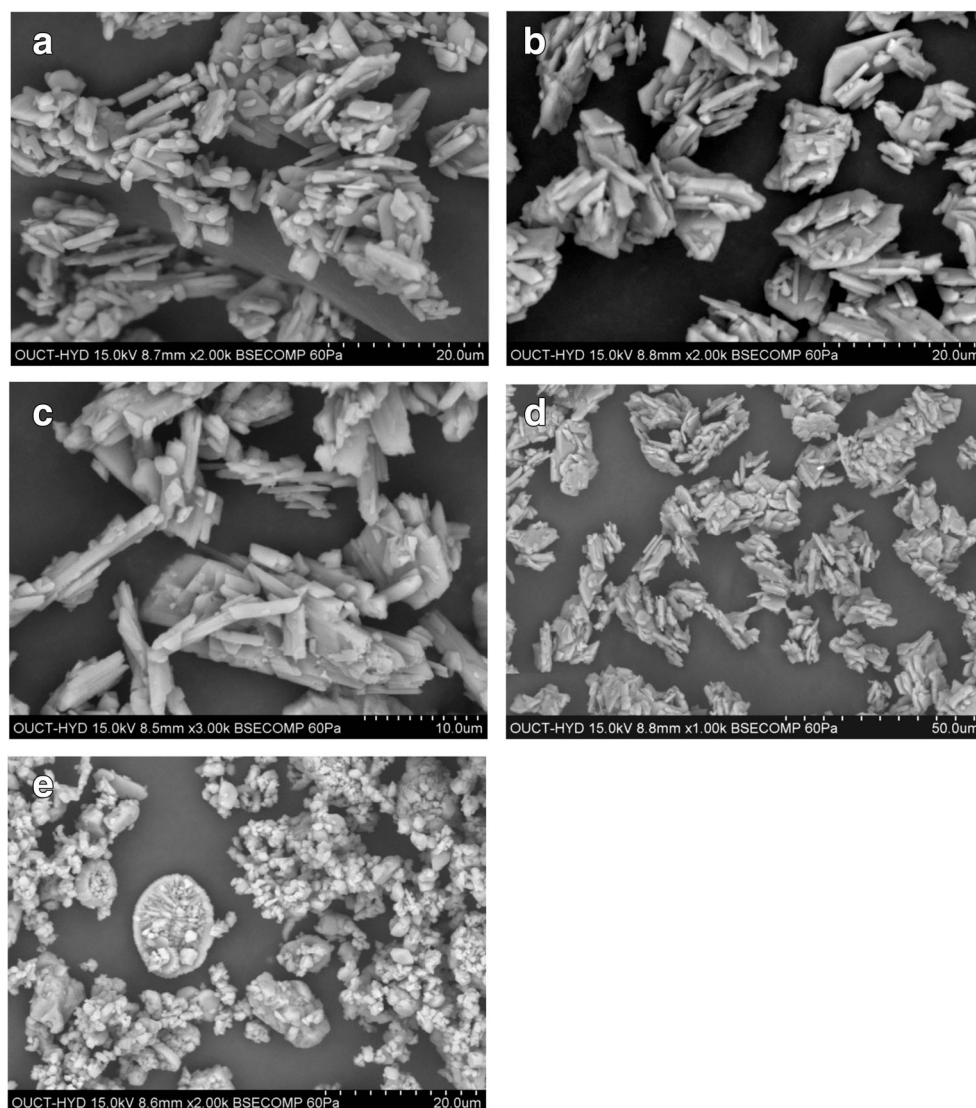


Table 4 Dose (mg kg⁻¹ day⁻¹) range of elements in each exposure pathway in the chalk dust

Element	Concentration	D.ing	D.inh	D.der	LADD
Al	2.88 ± 1.94	2.23E+06	2.6E+07	51.4E+06	4.2E-02
Cr	0.15 ± 0.06	0.11E+06	1.2E+07	2.7E+06	2.2E-01
Mn	0.89 ± 0.55	0.71E+06	8.3E+07	16.4E+06	1.3E+02
Fe	0.39 ± 0.35	0.31E+06	3.6E+07	7.1 E+06	5.8E-09
Co	0.18 ± 0.17	0.04E+06	4.0E+06	1.1E+06	2.6E-09
Ni	0.03 ± 0.02	0.82E+04	1.2E+06	5.1E+06	4.4E+03
Si	0.39 ± 0.28	0.3E+06	11.7E+07	7.1E+06	5.8E+03
Pb	0.18 ± 0.11	0.4E+05	4.0E+07	6.3E+06	2.6E+03

mg kg⁻¹ day⁻¹

like Ni (nickel) are in higher magnitude than the remaining elements. The results of different hazard quotient (HQ) values of different exposure pathways and hazard index (HI) of chalk dust particles are presented in Table 5. For non-carcinogenic effect, the dermal absorption is the major route for higher risk followed by the inhalation of chalk dust. This is because of the chalk dust that settles on the body parts and its surroundings and also the negligence of the teachers on hand washing

immediately after having lectures. The elements like Cr (chromium), Co (cobalt), and Ni (nickel) are analyzed for carcinogenic risk assessment. 9.2E-01, 2.75E-04, and 3.6E-02 are the range of risk noticed in the elements Cr (chromium), Co (cobalt), and Ni (nickel). It is also noticed that that cancer risk is lower than the recommended limits (10⁻⁶–10⁻⁴) indicating that these elements in chalk dust indicate that these elements cannot cause any carcinogenic effects to teachers [27]. With this result, the uncertainty of the elements in the chalk dust causing non-carcinogenic risk is proved. This study could not be carried out with all the available brands of chalk which could draw reasonable comparative account of composition and its related effects. Even with this limitation, risk assessment is proved to be a relevant tool to identify the elements and the exposure pathways of the most concern.

Conclusion

The concentrations of trace elements in chalk dust were estimated and elements like Al (aluminum), Mn (manganese), and Fe (iron) are noticed with higher concentration in both

Table 5 Hazard quotient (HQ) range of elements in each exposure pathway in the chalk dust

Element	Reference doses				Hazard quotient range				
	Ing Rfd	Inh Rfd	DerRfd	Slope factors	HQIng	HQinh	HQdermal	ΣHI	Cancer risk
Al	3.00E-04	1.43E-03	1.23E-04		5.41E-04	5.7E-03	15.7E-05	6.5E	-02
Cr	3.00E-03	2.8E-05	6.00E-05	4.20E+01 (Inh)	2.1E-04	3.6E-04	3.4E-06	4.0E	-03
9.2E-01									
Mn	14.0E-02	1.84E-03	18.4E-03		1.4E-04	4.8E-02	12.3E-07	5.9E	-01
Fe	8.00E-01	NA	NA		2.8E-03	3.0E-05	6.5E-04	2.1E	-03
Co	5.00E	5.71E-06	1.60E-02	9.80E+00 (Inh)	0.79E-02	1.9E-04	2.7E-03	2.8E	-04
2.5E-04									
Ni	2.00E-02	5.40E-03	2.00E-03	8.40E-01 (Inh)	1.09E-04	2.8E-02	8.3E-05	5.7E	-02
3.6E-02									
Si	5.00E-03	2.20E-03	NA		1.27E-03	2.3E-06	6.5E-05	3.4E	-03
Pb	3.5E-03	3.52E-02	5.25E-05		1.17E-04	3.1E-04	7.2E-04	8.8E	-01

settled and suspended chalk dust. The overall concentrations of the trace elements were high in suspended chalk dust in comparison with settled chalk dust which resembles the usage of the poor-quality chalks. The concentration of elements was compared with the ATSDR minimal risk levels. Cr (chromium), Mn (manganese), Fe (iron), Co (cobalt), and Ni (nickel) were beyond the minimal risk levels in both settled and suspended chalk dust. Minimal risk levels are not available for the elements Al (aluminum), Si (silicon), and Pb (lead). Image studies revealed that crystalline structures of chalk particles in chalk dust was limited to few samples whereas majority of chalk dust samples showed irregular flocs of chalk particles indicating poor-quality of chalks. The trace elements concentration was high in the suspended chalk dust; the fact can be correlated with the SEM images which have shown high density of absorbed chalk dust on filter papers. The major route of exposure to this chalk dust is dermal contact followed by the inhalation and ingestion. Al (aluminum), Fe (iron), Si (silicon), and manganese (Mn) are the major contributors for the non-carcinogenic effects. For all the elements, the carcinogenic effect calculated is within the global acceptable limit (10^{-6} – 10^{-4}).

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Authors' Contributions All the authors read and approved the final manuscript.

Compliance with Ethical Standards

Competing Interests The authors declare that they have no competing interest.

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