

Characterization of Water Soluble Inorganic Anions In Freefall Dust Collected From Rural Area Of R.S Pura Region, Jammu

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Abstract

Large scale industrialization and urbanization has led to the increasing levels of air pollution that alters the environment and human health etc. The study was conducted to evaluate the chemical concentrations of major ions (F^- , Cl^- , NO_3^- , SO_4^{2-} etc.) in dust samples collected from Government Schools in rural areas of Ranbir Singh Pura of Jammu region by using Ion exchange chromatography. Chemical characterization of indoor settled dust is important from the health point of view. The result shows that indoor dust is an important carrier of toxic substances; therefore proper care must be taken to reduce the indoor dust in the school environments.

Keywords: Ion, exchange, chromatography, toxic, substances, dust

Introduction

In past few decades, large scale industrialization and urbanization has led to the increasing levels of air pollution that alters the environment in harmful concentration by interfering with food chain and affects health and property also.

Depending upon their nature of existence, pollutants are classified as Quantitative pollutants (which normally occur in environment and acquire the status of pollutants when their concentration gets increased due to unmindful activities of man) and Qualitative pollutants (which don't occur in environment normally and are added by anthropogenic activities). Based upon their persistence form after being released into the environment, pollutants are categorized as:

Primary Pollutants	Sources	Effects
Sulphur dioxide (SO _x)	Volcanoes, Industrial processes, Coal and Industrial Processes	Acid rain (usually in presence of catalyst such as NO ₂ , forming H ₂ SO ₄)
Nitrogen oxides (NO _x)	High temperature combustion processes	Photochemical smog, Acid rain
Carbon monoxide (CO)	Incomplete combustion of fuel (natural gas, coal, wood, Vehicular exhaust)	Headaches, fatigue, nausea, dizziness
Carbon dioxide (CO ₂)	Emitted from combustion processes, Vehicular exhaust	Global warming
Volatile organic compounds (VOCs i.e methane and non-methane compounds)	Industrial processes	Leukemia, Cancer, Global warming
Particulate matter PM _{2.5} and PM ₁₀	Natural (volcanoes, dust storms, forest fires and Sea sprays) and Manmade (burning of fossil fuels in vehicles, power plants and industrial processes)	Lung Cancer, Heart diseases
Persistent free radicals	Air borne fine particles	Cardiopulmonary disease
Toxic metals	Traffic emissions, processes and atmospheric deposition	alter DNA causing Mutations, Cancer and Nervous system damage
Radioactive pollutants	Nuclear explosions, War explosives and by natural processes i.e decay of Radon	Damage DNA, mutation, Cancer
Secondary Pollutants	Sources	Effects
Particulate matter	Photochemical smog (vehicular exhaust and industrial emissions in presence of sunlight) and Classical Smog (i.e mixture of smoke and Sulphur dioxide due to combustion of fossil fuel)	Photochemical Smog And Classical smog
Ground level Ozone(O ₃)	Industrial processes and	Smog

	vehicular exhaust (NO _x and VOCs form O ₃)	
Peroxyacetyl nitrate (PAN)	NO _x and VOCs form PAN	Eye irritation, impaired breathing

Many researchers had carried out various studies regarding indoor pollution by carrying out roadside dust samples like **Fan et al. (2014)** studied organophosphate esters in settled indoor house dust. The method used was based on solvent extraction by sonication, sample cleanup by solid phase traction and analysis by gas chromatography- positive chemical ionization – tandem mass spectrometry. The result showed the presence of ethyl phosphate, phenyl phosphate, tris (chloropropyl) phosphate, tri (2-chloroethyl) phosphate, tris (dichloro- isopropyl) phosphate, tricresyl phosphate, and tri-n-butyl phosphate in the samples. **Kransnov et al., (2015)** studied the impact of increased indoor PM concentration which was controlled by atmospheric dust events and urban factors and thus PM₁₀ and PM_{2.5} levels were measured simultaneously in outdoor and indoor air during dust events. The results showed that during dust events average outdoor concentrations for PM₁₀ and PM_{2.5} may reach 551 μgm⁻³ and 299 μgm⁻³ respectively, which may have implications for air quality and health issues. **Spilak et al. (2015)** studied the Impact of dwelling characteristics on concentrations of bacteria, fungi, endotoxin and total inflammatory potential in settled dust and found that Indoor air in homes contain a variety of organic agents such as bacteria, fungi and endotoxin concentration in airborne dust collected by Electrostatic Dust fall Collectors. They concluded that people living in smaller dwellings on upper floors at higher risk of microbial exposures. The result showed that total Hazards Index for heavy metals was >1 for children and adults. **Reis et al., (2018)** studied the indoor and outdoor sources of potentially toxic elements. Oral bio-accessibility estimates by using Unified BARGE method and the chemical composition of toenail clippings were used to assess indoor dust ingestion as a potential exposure pathway and it was concluded that in indoor dust, Zinc and antimony contents arose as good predictors of toenail Zinc. **Naimabadi et al., (2020)** studied about the ten potentially toxic heavy metals in indoor dust from homes and found that the range of United States-Environmental Protection Agency Safe limits (1×10⁻⁴ and 1×10⁻⁶) indicates that cancer risk of Cr in age of both children and adults (1.6×10⁻³ and 5.5×10⁻³) is higher. **Al-Harbi et al., (2021)** studied the heavy metals associated with airborne particulate matter and the effect associated with heating, air conditioning and ventilation system that captures particulate matter with air filters containing 12.5 ± 5mg Co/kg dust to 14453 ± 5046 mg Fe/kg dust. Houses had high levels of Fe, Al, Zn and Mn and relatively low concentrations of As and Co.

Study area and Methodology

The present study was conducted to evaluate the various anions in dust samples collected from Government Schools in rural areas of Ranbir Singh Pura of Jammu region. The dust samples were collected from indoor environments and analyzed the major anions present in it. Jammu region features a humid subtropical climate with extreme summer reaching 46° C and in winter with average lows reaching 7°C and rainfall may total up to 669mm in the wettest month. The vegetation includes Mango, Jammun, Peepal, Eucalyptus and Dalbergia etc. in Ranbir Singh Pura. Wheat, Rice (Basmati), Maize, Bajra, Barley and Sugarcane are the crops that are cultivated here.

The main economic activities of Ranbir Singh Pura are agriculture and dairy farming. Silk textile, carpet making and woolen textile, forest based industries, agro based industries, pulp and paper mills, cement industry etc. in the industrial complexes.

Sampling:

Free dust samples were collected from nine schools from the rural area of Ranbir Singh Pura Zone of Jammu region in the month of May. Dust samples were collected from the windows, fans, desks, almirahs etc. of the classrooms. These samples are collected with the help of brush on the butter paper, this sample were then sieved off in order to remove the fibres, hair and other unwanted material and then was stored in the locked plastic bags.

Table No.1: Showing sampling locations in the study area

S.NO.	Sample	Site Name	Latitude	Longitude
1.	NIT-1	Government High School, Chakrohi.	32.539926	74.721193
2.	NIT-2	Government Primary School, Dangre.	32.543182	74.729068
3.	NIT-3	Raj High School Chakrohi.	32.546972	74.71713
4.	NIT-4	Indira Memorial School, Hansa.	32.543182	74.729068
5.	NIT-5	Government Primary School, Dewangarh.	32.533964	74.728065
6.	NIT-6	Kidi Care Public School, Sai.	32.523526	74.730541
7.	NIT-7	Government Higher Secondary School, Sai.	32.510321	74.724252
8.	NIT-8	Government Girls Primary School, Kerowal.	32.527337	74.732546
9.	NIT-9	Government Boys Primary School, Hansa.	32.561639	74.721408

Sample Preparation

In the first step, 1 gm of each sample was weighed with help of the weighing machine and then placed in the cleaned test tube. Each test tube was then filled with 10ml of milli-Q water. Then the test tubes were kept in oven at 50°C for 2 hours. Thereafter the test tubes were kept in the electric shaker for 6hrd. The samples were filtered with the help of Whatzman filter paper and final volume was made to 10ml and finally, the samples were stored in pre cleaned wide mouth propylene bottles.

Analysis

The dust samples were analyzed in the laboratory by using UV spectrometer. The major anions present in the samples are F^- , Cl^{2-} , NO_3^- , SO_4^{2-} etc. All samples were filtered using filter having pore size of $0.2\mu m$ before placing them in the auto sampler of ion chromatograph. Bicarbonate was analyzed using titration method.

Ion Chromatography

Ion exchange chromatography is a common method used for the analyzing major cations and major anions and can be used for the almost any kind of charged molecules including large proteins, small nucleotides and amino acids.

In an ion chromatograph, a sample is introduced, either manually or with an autosampler into a sample loop of known volume, a buffered aqueous solution known as the Mobile phase carries the sample from the loop onto a column that contains some form of stationary phase material, this is typically a resin or gel matrix consisting of agarose or cellulose beads with covalently bonded charged functional groups. The target analytes (anions) are retained on the stationary phase but can be eluted by increasing the concentration of similarly charged species that will displace the analyte ions from stationary phase. For example in cation exchange chromatography, the positively charged analytes could be displaced by addition of positively charged sodium ions. The analytes of interest must then be detected by some means, typically by conductivity or UV/Visible light absorbance. Prior to analyze all samples were filtered through a Teflon filter of $0.2\mu m$ pore size and diluted ten times by raising volume from 1ml to 10ml by adding milli-Q water. Diluted samples were poured into conical vials and placed in the autosampler.

Table No.2: Various ion chromatography parameters during analysis

Parameters	Anions
Data source	Conductivity detector 1(850 professional IC 1)
Recording time	21.0 mins

Column type	Metrosep C 4-150/4.0	
Eluent composition	Eluent A	Cation eluent -2.5 mm HNO ₃
	Eluent B	Not defined
	Eluent C	Not defined
Flow	0.900 mL/min	
Pressure	5.91 Mpa	

RESULTS AND DISCUSSIONS

In this chapter, results have been given and discussed. The Chemical concentrations of major ions (F⁻, Cl⁻, NO₃⁻, SO₄²⁻ etc.) are analyzed in the dust samples collected from different schools of rural areas of Ranbir Singh Pura region have been provided in table. A discussion on various chemical parameters has been provided as below:

Table No.3: Concentrations (in ppm) of major soluble anions in dust samples

Sample	Cl ⁻	NO ₃ ⁻	SO ₄ ²⁻	F ⁻
NIT-1	238.11	30.03	5436.32	2.14
NIT-2	697.14	41.18	4126.41	8.53
NIT-3	716.78	26.78	563.18	11.54
NIT-4	534.41	32.16	1086.36	3.16
NIT-5	837.09	20.68	548.44	2.70
NIT-6	916.19	242.1	5022.32	19.40
NIT-7	2810.76	--	6498.88	12.71
NIT-8	318.74	31.42	596.10	3.44
NIT-9	700.63	52.93	308.25	16.26

Fluoride is an inorganic, monatomic anion of fluorine. Its salts and minerals are important chemical reagents and industrial chemicals, mainly used in the production of hydrogen fluoride for fluorocarbons. Large influxes of fluoride in the environment, come from the coal combustion in indoor as well as outdoors. Combustion of coal and coal bricks is the primary source of fluoride and this fluoride can easily enter into exposed food products and ground water and thereby enter into human body. Intake of fluoride above permissible limit causes fluorosis. Chloride is considered a micronutrient since most plants require only trace amounts of Cl⁻ to meet their physiological requirements. However, chloride is associated with detrimental effects on soil salinity, salt intolerant crops, and crops which are vulnerable to Cl⁻ toxicity. In

the upper atmosphere, chlorine-containing organic molecules such as chlorofluorocarbons have been implicated in ozone depletion. Small quantities of elemental chlorine are generated by oxidation of chloride to hypochlorite in neutrophils as part of the immune response against bacteria. Nitrate salts are found naturally on earth as large deposits, particularly of nitratine, a major source of sodium nitrate. Nitrites are produced by a number of species of nitrifying bacteria, and the nitrate compounds for gunpowder were historically produced, in the absence of mineral nitrate sources, by means of various fermentation processes using urine and dung. Nitrates are found in manmade fertilizers. The determination of inorganic N, mainly NH_4^+ and NO_3^- in soil is often useful because these inorganic forms are readily available for plant uptake. Sulfate ion is a polyatomic anion with the empirical formula SO_4^{2-} and many of Sulfate anions are highly soluble in water. Exceptions include Calcium Sulfate, Strontium Sulfate, lead (II), and barium Sulfate, which are poorly soluble. Radium sulfate is the most insoluble sulfate known. The sulfate ion can act as a ligand attaching either by one oxygen (monodentate) or by two oxygens as either a chelate or a bridge. An example is the neutral metal complex $\text{PtSO}_4(\text{P}(\text{C}_6\text{H}_5)_3)_2$ where the sulfate ion is acting as a bidentate ligand. The metal-oxygen bonds in sulfate complexes can have significant covalent character. Under aerobic conditions, most of the inorganic S is present as sulfate.

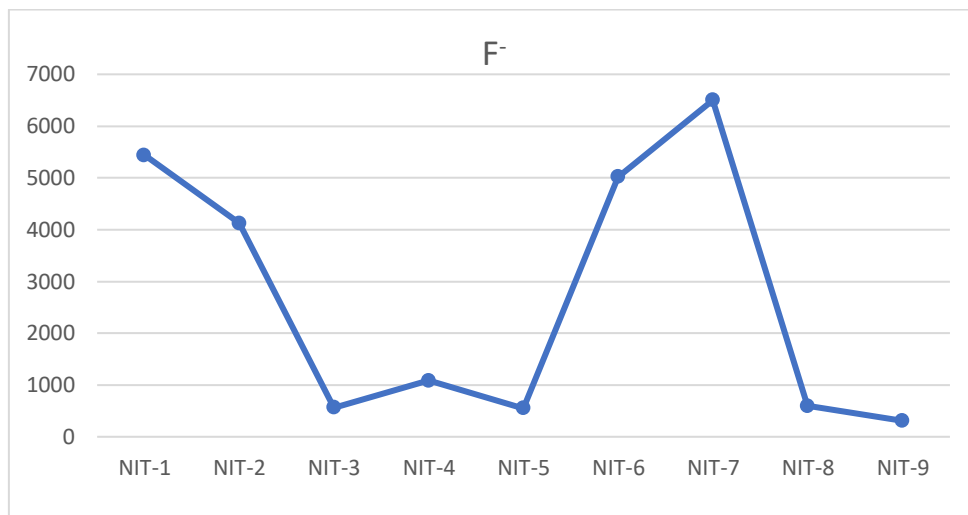


Fig. 1: Fluoride concentration in the study area.

In the samples, the fluoride concentration ranges from 2.14 to 19.40 ppm were observed. Highest fluoride concentration is found in the Kidi Care Public School, Sai; whereas lowest were reported from Govt. High School, Chakrohi. In general, Fluoride concentration followed the trend: $\text{NIT-6} > \text{NIT-9} > \text{NIT-7} > \text{NIT-3} > \text{NIT-2} > \text{NIT-8} > \text{NIT-4} > \text{NIT-5} > \text{NIT-1}$. The fluoride concentration in the range of 1.4-1.5 ppm were found

in the soil samples collected in the vicinity area of Zinc Smelter, Debari, Udaipur and Rajasthan(Bhat et al., 2015).

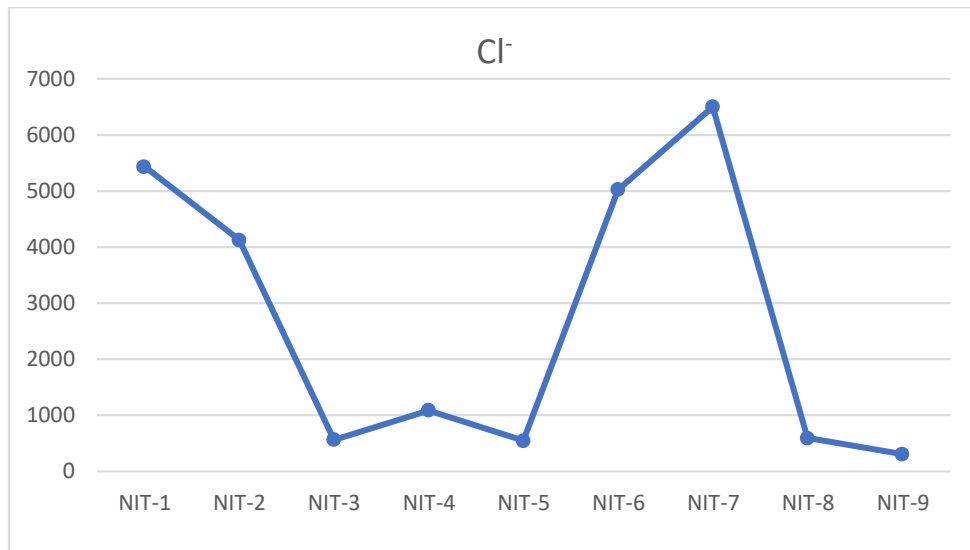


Fig. 2: Chloride concentration in dust samples.

In the samples studied the chloride ion concentration ranges from 238.11 to 2810.76 ppm were observed. Highest concentration of chloride ion is found in Government Higher Secondary School, Sai whereas lowest were reported from Government High School, Chakrohi. In general, chloride ion concentration followed the trend: NIT-7> NIT- 6 > NIT 5 > NIT-3 > NIT - 9 > NIT - 2 >NIT-4 >NIT-8 >NIT-1. In similar study, the concentration of chloride $1350\mu\text{g m}^{-3}$ was reported in the soil sample (Hameed and Khoder, 2004). In another study, the concentration of chloride $13.9\mu\text{g m}^{-3}$ was observed in indoor air of office environment (Kamal, 2004).

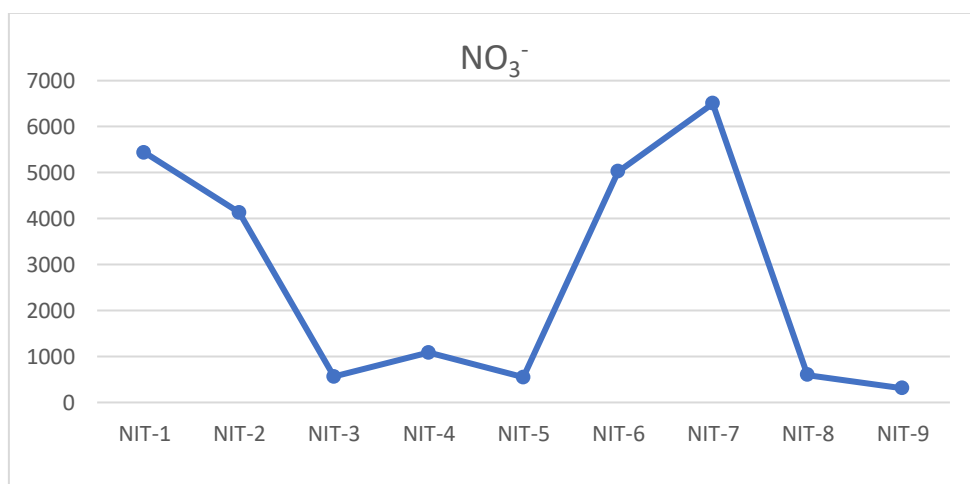


Fig. 3: Nitrate concentration in the dust samples.

In the samples studied, nitrate ion concentration ranges from 20.68 to 242.1. Highest concentration of Nitrate ion is found in Kidi Care Public School, Sai whereas lowest

in Government Primary School, Deewangarh. In general, nitrate ion concentration followed the trend: NIT-6>NIT-9>NIT-2>NIT-4 >NIT-8>NIT-1>NIT-3>NIT-5 .The concentration of available nitrate 1.24-49.60 mg / L was reported for the soil samples collected at different depth in Malaysia(Samira et al., 2009). The concentration of available nitrate was reported for the soil samples collected as 28 $\mu\text{g m}^{-3}$ (Hameed and Khoder, 2004). Also, the concentration of nitrate ion was detected in indoor air of office environment as 7.95 $\mu\text{g m}^{-3}$ (Kamal, 2004).

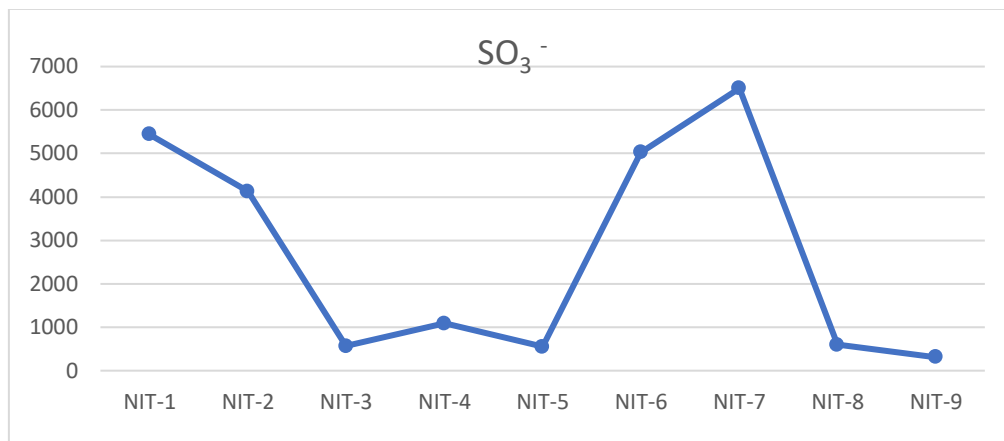


Fig. 4: Sulfate concentration in the dust samples.

In samples studied, sulfate ions concentration ranges from 308.25 to 6498.88. Highest sulfate ion concentration is found in the Government High School, Chakrohi whereas lowest value is reported in Government Higher Secondary School, Sai. In general, Sulfate ion concentration followed the trend: NIT - 1 > NIT - 6>NIT-2>NIT-4>NIT-8>NIT-3>NIT-5>NIT-9>NIT- 7.In another study, the concentration of available sulfate is 18 - 42 ppm was reported for the soil samples collected at different depth in Malaysia (Samira et al., 2009).). The concentration of available sulfate ion was reported for the soil samples collected as 64.9 $\mu\text{g m}^{-3}$ was observed in indoor air of office environment (Kamal, 2004).

CONCLUSIONS AND RECOMMENDATIONS

In the present study, we examined the various major anions present in the indoor dust samples collected from different schools of the Ranbir Singh Pura of Jammu. Overall, we collected nine samples and the major anions i.e. F^- , Cl^- , NO_3^- , SO_4^{2-} was analyzed using Ion Chromatograph. Fluoride is the simplest anion of fluorine ranges from 2.14 to 19.40 ppm in the sample studied. Chloride is considered a micronutrient since most plants require only trace amounts of Cl to meet their physiological requirements and concentration ranges from 238.11 to 2810.76 ppm in the sample studied. The determination of inorganic N, mainly NH_4 and NO_3^- in soil is often useful because these inorganic forms are readily available for plant uptake and concentration ranges from 20.68 to 242.1. Sulfates are known, and many of these are highly soluble in water and concentration ranges from 308.25 to 6498.88 in the sample studied.

Chemical characterization of indoor settled dust is important from the healthpoint of view. The Chemical concentrations of major ions (F^- , Cl^- , NO_3^- , SO_4^{2-} etc.) are analyzed in the dust samples collected from different schools of rural areas of Ranbir Singh Pura region. These ions have a natural origin; however these are added immensely in the environment by the burning of biomass, running of vehicles on the road causing pollution and because of industrialization. Burning of biomass around the surrounding areas of Jammu region especially in rural area of Ranbir Singh Pura could be an important source of the above given parameters. Source of fluoride ion is the coal that has been used in brick kilns and other industries as a source of energy. Combustion of coal and coal bricks is the primary source of fluoride and this fluoride can easily enter into exposed food products and ground water and thereby enter into human body. Intake of fluoride above permissible limit causes fluorosis. Indoor dust can be a major exposure route for some hazardous substances, leading to potential health risks. Inorganic water-soluble ions of dust are associated with the adverse human health effects, acidity of precipitation, and soiling of the monuments. They cause terrestrial and aquatic ecosystems damage. On the other hand, alkaline dust damages painted surfaces such as walls, doors and automobiles. Therefore, evaluation of chemical composition and characterization of household dust is important.

The result shows that indoor dust is an important carrier of toxic substances; therefore proper care must be taken to reduce the indoor dust in the school environments. Based on the results we propose following recommendations to reduce the dust load: Young children, especially are at higher risk from the ill effects of dust, therefore authorities must keep the indoor environment clean and maintain proper vegetation cover in the school premises to reduce the dust load. Road dust is one of the major sources of dust therefore proper sweeping of road must be done on regular basis to avoid dust dispersal. Under time and resources, the scope of this study is limited. We suggest that further work is needed to be comprehensively evaluating the inorganic as well as organic components of indoor dust to establish its importance from human point of view.

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