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Soil Ingestion Prevalence among School-Age Children in Ibadan, Nigeria

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Abstract

Soil ingestion is an important pathway of children's exposure to environmental contaminants. School-Age Children (SAC) behaviours and activities promote direct contact with soil leading to soil ingestion. However, limited studies have addressed soil ingestion among SAC in Africa. The study therefore assessed soil ingestion prevalence by age, gender and associated behaviours as well as activities among SAC. A cross-sectional study was conducted on 204 SAC aged 6 to 11 years old in Ibadan, Nigeria, using a semi-structured questionnaire. Fifty-four percent were females and children aged 9 – 10 years represented 51% of the population. Overall, previous prevalence of soil ingestion was high (74%) among the children. About 20% SAC, (6 – 8 and 9 – 11 years), 16% males and 14% females ingest soil often (generally when playing). SAC, 9 – 11 than 6 – 8 years had greater awareness (87% versus 72%) of harmful substances in the soil when consumed. Behaviours and activities involving direct contact with soil revealed: >50% SAC 6 – 8 years, males and females alike played with soil; males (83%) than females (65%) kicked soil during play; 5% (6 – 8 years); 7% (9 – 11 years); 2% (males) and 8% (females) picked dropped food all the time from any floor type with 33% females picking from bare soil. School playgrounds (61%) and compounds (83%) were bare soil. Proximity of schools to roads (87%) and heavy traffic (86%) was high. These school-age children practised soil ingestion. Age and gender influenced children's soil contact activities. Studies on soil ingestion among children is necessary to improve risks assessment from soil-borne contaminants.

La Prévalence De L'ingestion De Sol Chez Les Enfants D'âge Scolaire À Ibadan, au Nigéria

Résumé

L'ingestion de sol est une voie importante par laquelle des enfants se mettent vulnérables, aux contaminants environnementaux. Les comportements et les activités des enfants d'âge scolaire (les 'SAC'-School aged children) favorisent le contact direct avec le sol menant à l'ingestion de sol. Cependant, des études limitées ont abordé l'ingestion de sol parmi les 'SAC' en Afrique. L'étude a donc évalué la prévalence de l'ingestion de sol

selon l'âge et le sexe et les comportements et activités associés au sein des 'SAC'. Une étude transversale a été menée sur 204 enfants d'âge scolaire âgés de 6 à 11 ans à Ibadan, au Nigeria, à l'aide d'un questionnaire semi-structuré. Cinquante-quatre pour cent étaient des femmes et les enfants âgés de 9 à 10 ans représentaient 51 %. Dans l'ensemble, la prévalence antérieure de l'ingestion de sol était élevée (74 %). Environ 20 % des enfants (6 – 8 et 9 – 11 ans), 16 % des garçons et 14 % des filles ingèrent souvent de la terre (régulièrement lorsqu'ils jouent). Les enfants de 9 à 11 ans et de 6 à 8 ans étaient plus sensibilisés (87 % contre 72 %) aux substances nocives présentes dans le sol lorsqu'elles étaient consommées. Des comportements et des activités impliquant un contact direct avec le sol ont révélé : > 50 % des enfants d'âge scolaire 6 – 8 ans, les mâles et les femelles jouaient avec le sol ; les mâles (83 %) que les femelles (65 %) donnaient des coups de pied dans le sol pendant le jeu ; 5% (6 – 8 ans) ; 7 % (9 à 11 ans) ; 2 % (mâles) et 8 % (femelles) cueillaient constamment de la nourriture tombée sur n'importe quel type de sol, et 33 % des femelles cueillaient sur le sol nu. Les cours de récréation (61 %) et les enceintes (83 %) de l'école étaient en sol nu. La proximité des écoles aux routes (87 %) et à la circulation dense (86 %) était élevée. Ces enfants d'âge scolaire pratiquaient l'ingestion de sol. L'âge et le sexe ont influencé les activités de contact avec le sol des enfants. Des études sur l'ingestion de sol chez les enfants sont nécessaires pour améliorer l'évaluation des risques liés aux contaminants présents dans le sol.

Introduction

Soil ingestion is one of the primary pathways of children's exposure to a wide variety of environmental contaminants, such as heavy metals, pesticides and faecal contamination (Kwong *et al.,* 2021), particularly, contaminants that bind to soils (Moya and Philips, 2014). Although, exposure to environmental contaminants occur for both adults and children through soil ingestion, children are considered to be more exposed since they may ingest more soil because of their frequent hand-to-mouth, hand-to-object, mouthing of objects behaviours and contaminated food (U.S. EPA 2011; von Lindern *et al.,* 2016). Although, more unintentionally than deliberately, children can ingest significant quantities of soil in indoor environment from outdoor soil tracked into the indoor environments from shoes, pets and other sources while playing on the floor indoors (U.S. EPA, 2011; Moya and Philips, 2014). While the aforementioned can be said, more likely of younger children, older children playing outdoors can also ingest soil from various sources. Apart from deliberate hand-to-mouth movements, children may ingest soil and dust adhered to the hands and objects or do so, unintentionally by eating food that has dropped on the floor (U.S. EPA, 2011; Moya and Philips, 2014). Also, soil ingestion is an involuntary behaviour as part of mouthing and exploration in young children (Bauza *et al.,* 2017). Unintentional soil ingestion differs from other aspects of soil ingestion behaviour including soil-pica and geophagy. Consequently, U.S. EPA (2011) in their 'Exposure Factors Handbook' clearly defined all three as follows: Soil ingestion is the consumption of soil, resulting from but not limited to behaviours such as mouthing, contacting dirty hands, eating dropped food, or consuming soil directly. Soil pica is the recurrent ingestion of unusually high amounts of soil (i.e., in the order of 1,000- 5,000 mg/day or more) such as clays, yard soil, and flower-pot soil. Geophagy is the intentional ingestion of earths and is usually associated with cultural practices.

Soil ingestion has been linked to negative health outcomes such as diarrhoeal disease among under-five children in Kenya (Bauza *et al.,* 2017),

environmental enteropathy and stunting among young children (> 3 years) in Bangladesh (George *et al.,* 2015). Also, soil ingestion was associated with exposure to toxic non-residential pesticides among children aged 1 – 6 years in Washington State, USA (Simcox *et al.,* 1995). Malnutrition, anemia, diarrhoea, constipation and worm infestation have been reported more likely among children who practise geophagia (Shivoga and Mutori, 2009).

Children spend much of their time outdoors in close contact with soil (Hiller *et al.*, 2014). Those playing outdoors, are capable of unintentionally ingesting small amounts of soil that may reach up to 1,200 mg/day (Stanek and Calabrese, 1995). Consequently, incidental soil ingestion has been identified as the most important pathway of exposure when evaluating risks posed by contaminated soil (Calabrese *et al.,* 1997). Thus, understanding soil ingestion patterns is an important part of estimating overall exposures to environmental chemicals (U.S. EPA, 2011) and more importantly, for urban soils that are strongly affected by anthropogenic activities (Steffan *et al.*, 2018).

Children in low-income countries have substantially higher rates of soil and dust ingestion than children in high-income countries due to poor environmental conditions (Kwong *et al.,* 2021). Peculiar characteristics of low-income countries including, high population density, housing conditions-floors made of earth, bare soil for children playgrounds or areas, increased foot traffic transporting contaminated soil indoor. Inadequate sanitation facilities will also increase exposure through soil ingestion (Bauza *et al*., 2017; Kwong *et al.*, 2021). Additionally, children from low-income countries may also have different rates of placing soil-laden hands or objects in their mouths, thus, directly consuming soil (Kwong *et al.,* 2021) and are more likely to play bare foot in contaminated soil. The practice of soil ingestion among children aged 1 – 4 years may be insufficiently controlled when floors of most houses and yards are earthen (Shigova and Mutori, 2009).

School-Age Children (SAC) encompass children aged between 5 and 14 years who may or may not be enrolled in school (WHO, 2012). Specifically, school age cut-offs typically range from age 6 – 11/12 years, since majority of children usually start primary school by age 6 (OECD; 2020; Rao, 2021) and completion is by age 11 or 12 (Malmberg *et al.,* 2008). Children, including those of school age belong to the vulnerable and sensitive subgroup of the human population and are constantly exposed to environmental contaminants (Ferguson *et al.,* 2017). Children between the ages of 6 and 12 are in the age period commonly referred to as middle childhood.

Currently, soil ingestion studies are fewer for school-age children compared to under-five children. Additionally, there are very few soil ingestion studies on young children in low-income countries (Ngure *et al*., 2013; George *et al*, 2015), where soil ingestion is substantially higher than children in high-income countries (Kwong *et al*., 2021).

Therefore, this study assessed prevalence, behaviours and activities related to soil ingestion among school-age children and compared ingestion prevalence between childhood age groups and gender. It is important to note that the focus of this paper is on the prevalence based on survey responses of soil ingestion not on the amount ingested.

Materials and Methods

Study Area and Site

The study was conducted in Ibadan, Oyo State, located within latitude 7^{O} 26^{I} 55^{II} N and longitude 3^{O}57^{I} 45^{II} and a mean elevation of 167m above sea level. Total population and land area are 7, 840, 900, and 27,648 km^{2} (NPC, 2016). The City has over 3 million inhabitants (Adelekan, 2019). The study sites were primary schools (seven public and one private) situated along the Basorun-Akobo dual carriage road (heavy traffic) in Ibadan North-East and Lagelu LGA. Only one of the public schools was located in Ibadan North LGA. A semi-structured questionnaire was used to collect information on children's soil ingestion habits that could predispose them to several environmental contaminants.

Study Design and Participants

This paper is part of a larger study on concentration

of polycyclic aromatic hydrocarbon in soils of primary school environment in close proximity to traffic in Ibadan, Nigeria. Children in Class 1 - 6 present in the schools at the time of the survey (n = 204) were interviewed. Consequently, this paper focuses on the prevalence of soil ingestion among school-age children. Soil ingestion 'often' was defined as ingesting soil regularly each time a child had a chance to play after school, while soil ingestion 'sometimes', was defined as occasional ingesting soil while playing and soil ingestion 'never', was defined as non-ingestion of soil due to attendance of lessons or immediate return home after school closes.

Data Analysis and Ethics

Data was analysed using descriptive statistics to derive mean values, standard deviation and tables of frequency. All data was processed by Microsoft Excel and SPSS. Since public and private primary schools were involved, ethical approval with reference number AD 13/479/1738[A] was obtained from Oyo State Research Ethics Review Committee, Ministry of Health Secretariat, Ibadan. The study was conducted in a school involving non-invasive procedures therefore, informed consent was obtained from the headmaster /mistress and assent from the children before commencement of the study.

Results

Socio-demographic Characteristics

The distribution of the study participants (Table 1) was relatively homogeneous in terms of gender; 111 (54%) of the 204 pupils aged 6 – 11 were females and 93 (46%) males. Children aged 9 – 10 years represented 51% of the study population, while 33% of the population belonged to age 6 – 8 years and only a few (16%) were aged 11 years.

The greater proportion (56%) of the children were in class 4 to 6, while 44% were in class 1 – 3. Separating the entire study population into two groups belonging to the middle childhood years of 6 – 8 and 9 – 11 years showed the latter represented the majority (137; 67%).

Table 1: Socio-demographic characteristics

Socio-demographic characteristics	Mean Age (±SD)	Median Age	p-value	Frequency (n = 204)	Percentage (%)
Gender					
Male				93	45.6
Female				111	54.4
Age (years)					
6				26	12.7
7	6.9 ± 0.8	7		22	10.8
8			0.000	19	9.3
9				44	21.6
10	9.9 ± 0.8	10		60	29.4
11				33	16.2
Class					
Pry 1				29	14.2
Pry 2				27	13.2
Pry 3				34	16.7
Pry 4				37	18.1
Pry 5				38	18.6
Pry 6				39	19.1
Religion					
Christianity				132	64.7
Islam				72	35.3

Prevalence of Soil Ingestion by Children's Age Group

Tables 2 and 3 present responses to questions on children soil ingestion behaviours and activities that potentially involve contact with soil. Overall, previous soil ingestion among SAC in this study was high (74%; Table 2). Similar response on previous soil ingestion ranging from 68% to 74% was reported for children aged 6 to 10 years but was higher (91%) for children aged 11 (Table 2). Also, previous soil ingestion in children groups aged 6 – 8 and 9 – 11 years was similar (70% and 75%, respectively; Table 3). About 20% of childhood groups aged 6 – 8 and 9 – 11 years (Table 3) practised soil ingestion often, that is regularly when playing on the playground in school, while one third (33%) of the children in age group 6 – 8 years and nearly a quarter (26%) of the children age 9 – 11 years reported this behaviour occurred only sometimes (occasional soil ingestion while playing). As regards children awareness (Table 3) on presence of harmful substances in the soil, most children reported high awareness but more children aged 9 – 11 years than 6 – 8 years had greater awareness (87% *versus* 72%).

With regard to children's activities involving direct contact with soil, SAC reported play-related behaviours (playing with soil, rubbing soil on the body, kicking soil, games or sports on soil) and picking food from the floor (Table 3). More than half of the children aged 6 – 8 years played with soil when school closes (58%) and rubbed soil on their body while playing (57%). Majority of children (75%) aged 6 – 8 than older children (53%) aged 9 – 11 years kicked soil while playing. Across all age groups, playing games or sport on bare soil was high, accounting for 81% and 88% among 6 – 8 year and 9 – 11 years old, respectively. Amongst the age groups, fewer children aged 6 - 8 (5%) than 9 – 11 years (7%) reported picking fallen food all the time, indicating that, children always picked fallen food immediately from the floor regardless of the environment. More children age 6 – 8 than 9 – 11 reported picking fallen food occasionally (36% *versus* 17%). This response implied that fallen food was not usually picked except when dropped accidentally. More than half of the children in the age groups reported never picking fallen food from the floor. However, of those who picked fallen food, many children reported picking from concrete floor.

Prevalence of Soil Ingestion by Gender

In terms of gender (Table 4), previous soil ingestion was high and similar among males (73%) and females (74%). More males (45%) than females (37%) crave ingesting soil. At the time of the study, 16% and 14% males and females, respectively, reported they often ingested soil when playing on the playground in school, implying more males consumed soil regularly compared to

Table 2: Response to question on previous soil ingestion among children by age

Behaviour		Response			
		Yes		No	
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Ever consumed soil previously					
6 years	(n = 26)	18	69.2	8	30.8
7 years	(n = 22)	15	68.2	7	31.8
8 years	(n = 19)	14	73.7	5	26.3
9 years	(n = 44)	30	68.2	14	31.8
10 years	(n = 60)	43	71.7	17	28.3
11 years	(n = 33)	30	90.9	3	9.1
Total	204	150		54	
Mean			**73.7**		**26.4**

the females. Thirty-seven percent male children reported ingesting soil sometimes, meaning they rarely practised soil ingestion. The percentage of children who never ingested any soil accounted for 47% and 56% males and females, respectively. Children who reported never ingesting soil only accounted for non-consumption of soil in school since they did not play but either attended after-school lessons or returned home immediately school closes.

In terms of gender, nearly all males (86%) and females (88%) were equally aware of the presence of substances in the soil that cause harm when soil is consumed.

Table 3: Soil ingestion behaviour and direct soil contact activities among children groups

Variables	Age groups (years)			
	6 – 8	9 – 11	6 – 8	9 – 11
	Frequency		Percentage	
	n = 67	n = 137	%	%
Soil ingestion activities				
Craving soil† ingestion				
Yes	32	67	47.8	48.9
No	35	70	52.2	51.1
Ever consumed soil previously				
Yes	47	103	70.2	75.2
No	20	34	29.9	24.8
Current soil ingestion behaviour				
Often	13	28	19.4	20.4
Sometimes	22	35	32.8	25.6
Never	32	74	47.8	54.0
Awareness of harmful substance via soil ingestion				
Harmful substances in the soil				
Yes	48	119	71.6	86.9
No	19	18	28.4	13.1
Activities involving direct contact with soil				
Playing with soil after school				
Yes	39	69	58.2	50.4
No	28	68	41.8	49.6
Rubbing soil on body while playing				
Yes	38	74	56.7	54.0
No	29	63	43.3	46.0
Kicking soil while playing				
Yes	50	72	74.6	52.6
No	17	65	25.4	47.5
Play games/sport on the soil†				
Yes	54	120	80.6	87.6
No	13	17	19.4	12.4
Pick food from the floor				
All the time	3	9	4.5	6.6
Occasionally	24	23	35.8	16.8
Rarely	6	17	9.0	12.4
Not at all	34	88	50.8	64.2
Floor type where food is picked from	**n = 33**	**n = 48**		
Concrete	19	34	57.6	70.8
Soil	7	13	21.2	27.1
Tiles	7	1	21.2	2.1
Wood	0	0	-	-
Others	0	0	-	-

†- the word 'sand' was used to represent soil to ensure easy understanding for the children

Considering behaviours related to soil contact by gender, (Table 4) revealed more than half of the children, either male (56%) or female (51%) played with soil when school closes. Generally, more males than females were involved in soil-related activities. Kicking of soil while playing was more likely practised by males than females (83% *versus* 65%) and nearly all children (>80%) regardless of gender participated in games and sports. Very few males (2 out of 93) and females (9 out of 111), accounting for 2% and 8% picked fallen food all the time from any type of floor. This

Table 4: Soil ingestion among school-age children by gender

Variables	Gender			
	Male		Female	
	Frequency (n = 93)	Percentage (%)	Frequency (n = 111)	Percentage (%)
Soil ingestion activities				
Craving soil† ingestion				
Yes	42	45.2	41	36.9
No	51	54.8	70	63.1
Ever consumed soil previously				
Yes	68	73.1	82	73.9
No	25	26.9	29	26.1
Current soil ingestion behaviour				
Often	15	16.1	16	14.4
Sometimes	34	36.6	33	29.7
Never	44	47.3	62	55.9
Awareness of harmful substance via soil ingestion				
Harmful substances in the soil				
Yes	80	86.0	98	88.3
No	13	14.0	13	11.7
Activities involving direct contact with soil				
Playing with soil after school				
Yes	52	55.9	56	50.5
No	41	44.1	55	49.6
Rubbing soil on body while playing				
Yes	57	61.3	56	50.5
No	36	38.7	55	49.6
Kicking soil while playing				
Yes	77	82.8	72	64.9
No	16	17.2	39	35.1
Play games/sport on the soil†				
Yes	83	89.3	91	82.0
No	10	10.8	20	18.0
Pick food from the floor				
All the time	2	2.2	9	8.1
Occasionally	28	30.1	19	17.1
Rarely	13	14.0	11	9.9
Not at all	50	53.8	72	64.9
Floor type where food is picked from	**(n = 43)**		**(n = 39)**	
Concrete	28	65.1	25	64.1
Soil	8	18.6	13	33.3
Tiles	7	16.3	1	2.6
Wood	0	-	0	-
Others	0	-	0	-

† - the word 'sand' was used to represent soil to ensure easy understanding for the children

behaviour was however, practised occasionally by 30% male children, while more than half of the children reported never picking fallen food. Of those who picked fallen food, more children (> 60%) either male or female picked from concrete floor. It is interesting to note that one third of the female children picked fallen food from bare soil.

School Surrounding Characteristics

On the outdoor characteristics (Table 5), all schools in the study had a playground and 61% was bare soil while 39% had grass cover. Nearly all school compounds (83%) were bare soil and only 15% had grass cover. Eighty-five percent of classroom in the study had concrete floor, only two classroom floors accounting for 1% was bare soil. Children may be exposed to soil-associated contaminants from anthropogenic sources such as emissions from traffic and industries. Most of the children in this study reported their schools were in close proximity to roads (87%), constant heavy traffic (86%) and factories (85%). Forty-eight percent of the children reported the presence of mechanical workshops, 24% reported livestock feed-mills and a few (13%) reported petrol stations as type of factories close to their school.

Table 5: Characteristics of school surroundings

Variables	Frequency (n = 204)	Percentage (%)
Presence of playground in school		
Yes	204	100
No	0	-
Characteristics of school playground		
Soil †	125	61.3
Grass	79	38.7
Characteristics of school compound		
Soil	170	83.3
Grass	30	14.7
Concrete	4	2.0
Characteristics of classroom floor		
Concrete	173	84.8
Others (Terrazzo)	28	13.7
Soil	2	1.0
Tiles	1	0.5
School's proximity to road		
Yes	177	86.8
No	27	13.2
Constant traffic around school		
Yes	176	86.3
No	28	13.7
Presence of factories around school		
Yes	174	85.3
No	30	14.7
Types of factories around school (Multi-response)		
Mechanic workshop	98	48.0
Petrol station	27	13.2
Feed-mill	50	24.0

† - the word 'sand' was used to represent soil to ensure easy understanding for the children

Table 6: Soil ingestion studies on children in Africa

Location	Soil-Ingestion Studies	Age Group (years)	References
Ghana	Pica Practices among apparently healthy women and their young children in Ghana	1-5	Abu *et al*, 2002
Kenya	Soil ingestion is associated with child diarrhea in an urban slum of Nairobi, Kenya	0-5	Bauza *et al*, 2017
Western Kenya	Geophagy among school children in Western Kenya	5-18	Geisssler *et al*, 1997
Western Kenya	The significance of earth-eating : social and cultural aspects of geophagy among Luo children	NA	Geisssler, 2000
South-Africa	Geophagy and its association with geohelminth infection in rural school children from northern Kwazulu -Natal, South Africa	9-14	Saathoff *et al*, 2002

NA – not available

Discussion

This study has largely addressed the prevalence of soil ingestion among school-age children through the survey response method (Doyle *et al.,* 2012), with questions concerning the frequency of soil ingestion and involvement in behaviours and activities that bring them into direct soil contact. Soil ingestion among School-Age Children (SAC) in Africa has received very little attention. Table 6 revealed that very few studies on soil ingestion are currently available in Africa. However, on a global basis, previous studies have focused more on under-five children (George et al. 2015; Bauza *et al.*, 2017; Kwong *et al.,* 2021) with scanty studies on SAC (Geissler et al. 1997; Lin *et al.,* 2017). The high prevalence of soil ingestion in this study shows the practice to be widespread among school children, consistent with an earlier study in Kenya (Geissler *et al.,* 1997).

Demographic factors, such as age and gender have been reported to influence the rate of soil ingestion (Moya and Phillips, 2014). Previous prevalence of soil ingestion among SAC was high regardless of childhood age groups and gender. Older children (11 years old) reported highest previous soil ingestion implying soil consumption for over a relatively longer period compared to the younger children in this study. This was further demonstrated with children aged 9 – 11 years who had higher soil ingestion prevalence than those aged 6 – 8 years. Current ingestion of soil was however, relatively low but was practised by children across all ages. Even though intentional ingestion of soil was not the focus of this study, response to the question on current soil ingestion among SAC disclosed their current soil ingestion behaviours. It was established that about a fifth of the children in the two childhood age groups practised consumption of soil regularly each time they played especially at the school playground. Higher proportion of children aged 6 – 8 years practised soil ingestion sometimes compared with those aged 9 – 11 years. Reported prevalence of soil ingestion among $\leq$ 5 years decreased with increased age (Bauza *et al.,* 2017). The response 'sometimes' implied occasional soil ingestion while playing. The presence of soil in the immediate environment at the point of play (playground) and surrounding of majority of the school compounds in this study is likely to motivate intentional ingestion of soil in children. This is consistent with a previous study that assessed soil ingestion among under-five children who were not constantly restricted indoors in an urban slum with presence of soil in their immediate surroundings (Bauza *et al.,* 2017).

Although, the quantity of soil ingested by children was not determined in this study, a recent study reported that children in lower-income countries ingest substantially more soil than their counterparts in high-income countries. This was attributed to a high prevalence of direct soil ingestion on a daily basis and frequent contact with soil in both outdoors and indoors (via earthen floors) that result in high soil loads on hands that are infrequently washed (Kwong *et al.,* 2021).

Gender influences prevalence of soil ingestion and children behaviour and activities that bring them in direct contact with soil. The findings in this study revealed more males consumed soil

regularly or even occasionally compared to females of whom a higher proportion never practised soil ingestion. Non-consumption of soil was reported only in school. This study did not account for soil ingestion outside school hours. Higher prevalence of soil ingestion among males than females in this study is in contrast with a previous study on geophagy in Ghana that reported soil ingestion was less frequent in males than in females (Kortei *et al.,* 2020).

Children are generally less aware of soil-borne hazards, thus they are more exposed to a range of environmental contaminants including lead, pesticides, and fecal contamination through the ingestion of soil and dust (Moya and Phillips, 2014; Kwong *et al.*, 2021). Direct ingestion of soil has been stated to be the predominant exposure pathway for most, heavy metals and non-volatile contaminants (Doyle *et al.,* 2012). Young children in the early childhood stage have very little awareness of the concept of contamination or disgust concerning things they ingest (Calabrese *et al.,* 1997). Compared to early childhood, the middle childhood category in this study demonstrated high awareness of harmful substances in the soil, with increased awareness among the older children (aged 9 – 11 years).

Certain children's behaviours and activities may bring them in close and continual contact with the soil which may result into inadvertent or intentional ingestion of soil because of their inability to judge the risk associated with soil consumption. These behaviours and activities involving direct contact with soil revealed more participation of younger middle childhood age than their older counterparts in this study. For instance, far more children aged 6 – 8 years kicked soil while playing compared to those aged 9 – 11 years. Again, two times greater the proportion of children aged 6 – 8 years than those older, picked dropped food from the floor occasionally. Children are likely to have extensive soil contact from playground, school environment or backyard (Calabrese *et al.,* 1997). Generally, more males than females participated in activities that involved direct contact with soil. Although a low response was recorded in cases where some females picked food from the floor regularly. Soil ingestion may occur inadvertently via ingestion of soil that adheres to food that falls on the floor or bare soil. Other activities such as playing on bare soil and kicking of soil will increase children's exposure to soil-borne contaminants.

Additionally, school surrounding characteristics will increase children's direct contact with soil. Presence of bare soil in the immediate surrounding or environment of many of the schools and classroom floors serve as a direct exposure to soil for the children in this study. A study in an urban slum in Kenya demonstrated child exposure to soil in households with non-earth floors (Bauza *et al.,* 2017), implying multiple exposure points for children in lower-income countries as it is the case in this study. School environment was more often than not, encompassed about with bare soil in playgrounds, classroom verandas, uncultivated flower beds and damaged classroom floors. Upgrading earthen floors to concrete or other non-earth materials may not necessary eliminate soil from the vicinity of children in low-income countries (Bauza *et al.,* 2017). Soil can be brought indoors from increased foot traffic on bare soil close to buildings in low-income settings (Bauza *et al.,* 2017), thereby increasing the exposure of children to soil and soil-associated contaminants. Furthermore, the proximity to heavy traffic roads and small scale factories within the neighbourhood of these schools may contaminate soils of schools. From literature, it has been established that soil can become contaminated as a result of direct or indirect discharges, atmospheric deposition of contaminants, runoff flow from contaminated areas and other processes (Moya and Phillips, 2014).

Conclusion

Soil ingestion studies have not been the focus of extensive research in Africa and more specifically in Nigeria. This study represents one of the few soil ingestion studies in Africa. The study found high practice of previous soil ingestion regardless of children's age group and gender; indicating a widespread practice among school children. Current prevalence of soil ingestion was relatively

low but practised regularly by a fifth of the children across all ages each time they played at the school playground. Direct ingestion of soil suggests exposure of these children to soil-borne contaminants, especially those schools with proximity to heavy traffic roads. Further, the study demonstrated children's high awareness of harmful substances in the soil, with increased awareness among the older children. Children in this study are likely to practice soil ingestion inadvertently or intentionally not only due to certain behaviours and activities that promoted close and continual soil contact but by the presence of large areas of bare soil in their immediate environment at the playground and surroundings of schools. This study had the limitation of not quantifying amounts of soil ingested by the school-age children in this study but rather used the survey response method only for assessing soil ingestion. Soil ingestion rate and adverse health effects associated with consumption of contaminated soils especially by children which is a rare component of public health researches requires further investigation.

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