

CLEANING EFFICIENCY REGARDING INDOOR AIR QUALITY IN ROMANIAN SCHOOLS

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Abstract: Cleaning products are used in everyday life in schools bringing numerous benefits, such as dust removal or preventing the spread of infections. However, exposure to chemicals that are constituents of these products may cause functional and organic damage. Since the exposure depends on the product type and the conditions under which they are used, the aim of this study was to assess cleaning procedures used in schools from Romania, and also to evaluate comfort parameters, critical in the formation and evolution of indoor pollutants. The experimental study was carried out in two classrooms by applying a checklist for classrooms and measurements of comfort parameters. Dry cleaning activities and sweeping the floors were the most frequent; also, not using vacuums were considered quite ineffective. Poor ventilation and comfort parameters that reached certain levels, supplied good conditions for the formation of secondary organic aerosols, and present a risk to children's health.

INTRODUCTION

Preventing the spread of infectious diseases that may be transmitted through hand contact with surfaces is the main objective of cleaning. This activity refers to the removal of soil and organic contamination using the physical action of scrubbing together with the chemical action of a surfactant or detergent and water. When needed, cleaning precedes the disinfection of surfaces, especially those with visible contamination.(1)

However, cleaning is not without risks. The substances used to facilitate dust and dirt removal and the disinfection agents are source of chemical hazards. Indoor uses of these products can lead building occupants of inhalation exposure to numerous airborne chemicals.(2)

Cleaning products have, nowadays, a wide variety of applications like the removal of dust, viruses, bacteria, particulates, endotoxins, allergens and mould. Constituents from these products can react with pre-existing indoor oxidants and yield potentially harmful secondary pollutants including ultrafine particles and airborne chemicals.(3) For example, secondary organic aerosols (SOAs) are the result of the reaction between indoor ozone and the biogenic volatile organic compounds (BVOCs) emitted from household cleaning products.(2) All of these indoor contaminants can have an impact over human health. VOCs can cause eye, nose and throat irritation, cough, headache, skin irritation or even trigger allergies and asthma. Others produce unpleasant odours.(4) The formation of indoor SOAs depends on particular physical parameters such as air exchange rates, relative humidity and temperature.(5)

The exposure depends on the type of products used and the conditions under which they are used, such as frequency, amount, manner of application, and efficiency of ventilation during and after cleaning (4), applying a checklist for classrooms and measurements of comfort parameters (temperature and humidity) in classrooms.

Indoor air quality and its association with human

health impact, as well as remedial measures have been studied less in schools than in other types of buildings. A good indoor air quality in schools is essential to ensure a safe, healthy and comfortable environment for children, teachers and staff.(6,7)

Children are more exposed than adults due to their dynamic developmental physiology which may be handled quite differently by their immature set of systems. Also, they have special susceptibilities to exposure because of their hand-to-mouth behaviour, ignorance of risks, being close to the ground while playing and their behaviour as explorers and investigators (touching and tasting).(8) Low-dose exposures may produce undetected or subtle effects, which may be difficult to diagnose.(9,10)

Given the discussion above, the incorrect use of certain cleaning products in schools (e.g. over dosage, mixing of different products, inappropriate cleaning methods) can increase children's exposure to indoor contaminants from cleaners.

PURPOSE

The aim of this experimental study was to assess the cleaning procedures used in schools from Romania, as an important factor in controlling the indoor pollution level, and also to evaluate the comfort parameters that are critical in the formation and evolution of indoor pollutants.

MATERIALS AND METHODS

The experimental study was carried out in “Avram Iancu” secondary school in Unirea village, in December 2014, in the classroom with identification code S1 and in “Axente Sever” secondary school in Aiud city, in the classroom with identification code S2, both in Alba County, Romania. The schools were chosen so as to cover both rural and urban areas.

In order to meet the purpose of the study, two methods were used: applying a checklist for classrooms and measurements of comfort parameters (temperature and humidity) in classrooms.

Checklists were filled in following observational

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assessment of the classrooms, together with teachers and the cleaning personnel. Information followed was related to cleaning (frequency, substances used) and ventilation (frequency/number of opened windows on a seasonal basis).

In each classroom, measurements of comfort parameters were done during school day. There had been established 6 sampling periods, starting at 6 a.m. until 12 p.m. for 50 minutes each and 10 minutes ventilation between them, done by opening windows according to normal usage to establish their evolution over a school day. The sampling was performed by using a gas analyzer IAQ-CALC model 7545 TSI that also monitor temperature and humidity. It displayed maximum and minimum values, and also 50-min means were calculated. Teachers and children were asked to perform normally all activities.

RESULTS

After analyzing the two checklists, the cleaning personnel of the schools stated their activities had been done approximately the same way, and yet, classroom S1 was very dusty and the floor and desks were dirty, unlike classroom S2, which was clean.

Results regarding the frequency of cleaning activities for classroom S1 are shown in table no. 1.

Table no. 1. Frequency of cleaning activities in S1

Daily	1/week	1/month	1/year	Never
empty trash	walls dusted	windows washed	walls washed	vacuum
sweeping	ceiling dusted		ceiling washed	polish floor
floor scrubbing	other surf. dusted		polish other surf.	
dusting	polish surf.		curtains washed	

As seen in the table above, emptying the trash, sweeping and scrubbing the floor and dusting the main surfaces (e.g. children's benches, teacher's desk) were done on a daily basis. Once a week, walls, ceiling and other surfaces (doors, closets) were dusted and main surfaces polished. Vacuuming and floor polishing were not used in cleaning activities.

Further on, results on cleaning activities frequency for classroom S2 are shown in table no. 2. Unlike in S1, floor scrubbing was done only once a week. Floor sweeping and dusting other surfaces was done once a week, but walls and ceiling were dusted only once a month. In contrast to S1, in this classroom polishing the floor took part of the cleaning activities.

Table no. 2. Frequency of cleaning activities in S2

Daily	1/week	1/month	1/year	Never
empty trash	floor scrubbing	polish floor	curtains washed	vacuum
sweeping floor	other surf. dusted	walls dusted		walls washed
dusting		ceiling dusted		ceiling washed
		other surf. dusted		
		polish surf.		
		windows washed		

In both classes, a disinfectant-free detergent was used for washing the floorings, spray for polishing the surfaces, liquid polishing products for polishing the floors (only in S2) and ammonia-free detergent for washing the windows.

Results for ventilation on a seasonal basis are presented in table no. 3 for both classrooms.

Table no. 3. Frequency of opening the windows in the two classrooms

	S1		S2	
	winter	summer	winter	summer
windows opened	2 /day	-	2/day	-
number of windows opened	0	1-2	1	2
open windows before classes start	yes	yes	yes	yes
open windows during breaks	no	no	yes	yes
open windows during classes	no	no	yes	yes
open windows after classes end	yes	yes	yes	yes
open windows during night	no	no	no	no
open windows during cleaning	yes	yes	yes	yes

Classrooms were ventilated differently, in classroom S1 windows were opened less often compared to classroom S2. In the first classroom, windows were opened only before teaching hours begun, after they ended and during cleaning, unlike the second classroom where, windows were also opened during classes or breaks, if necessary.

Direct measurements of comfort parameters in S1 showed that during school hours, inside room temperature fluctuated between 17.5 and 19.5°C (median: 18.6°C) and relative humidity ranged between 57 and 70% (median: 62%). In classroom S2 temperature ranged between 17.1 and 22.9°C (median: 20.9°C) and relative humidity between 49 and 63% (median: 57%).

DISCUSSIONS

Dry cleaning activities, like sweeping floors and surfaces dusted, had been done on a daily basis in both classrooms. This type of cleaning stirs up dust, mixing it with the breathing air. Dry dusting disperses particles into the air immediately, while the use of spray-polish could diminish this dispersion phenomenon.(11)

Dust particles may contain hundreds of chemically or biologically active components. They can enter the human body via several exposure routes, such as skin contact, absorption through mucosal membranes of the eyes, inhalation or swallowing and digestion.(12) In an experimental study, dust from vacuum cleaner bags from seven Danish office buildings was analysed; micro-organisms (bacteria, viruses, mould), VOCs (mostly aldehydes), and semi-VOCs, plastic softeners (dibutyl phthalate (DBP) and di-(2-ethylhexyl)-phthalate (DEHP) had been detected as well as non volatile compounds such as surfactants, quartz, minerals and other inorganic substances such as trace metals.(4) These being said, not vacuuming dust in classrooms makes the indoor exposure to pollutants even higher.

Another major concern however, is children's inhalation of BVOC's from cleaning products since organic chemicals are widely used as ingredients. Studies showed that monoterpenes and oxygenated monoterpenes species (major components BVOCs), concentration levels were determined mainly due to the consumption of cleaning products and air fresheners indoors.(2) They react rapidly with ozone to form secondary pollutants, including secondary organic aerosols (SOAs), carbonyl compounds (acetone, formaldehyde and methyl ethyl ketone) reaction and reactive hydroxyl radicals.(13) Non-volatile constituents of cleaning products can also be inhaled, either because the cleaning process itself releases particulate matter into the air and forms aerosols, or because residual cleaning materials are later suspended, for example, through abrasion and wear. This can be the case after floors are scrubbed (once a day in S1 or once a week in S2) or surfaces are polished, windows washed mostly once a month in the evaluated classrooms.

Higher ventilation rate can dilute the BVOCs in the

indoor environment, resulting in a less ultrafine particle formation in the presence of ozone, as stated in a study.(2) This was not the case for the classrooms that took part of this study. It is important that in both windows were opened during cleaning activities, but in the rest of the time, especially in the winter time, ventilation was poor.

As stated before, the formation of indoor SOAs depends on particular physical parameters such as relative humidity and temperature. In their study, Pathak et al. (14) showed that the SOAs resulted from ozonolysis of pinene had a weak association with temperatures between 15 and 40⁰ C and a stronger dependence in the range of 0 and 15⁰ C, the amount of SOAs formed at 17⁰ C being approximately 5–6 times higher than that at 45⁰ C (2). In our study, temperature medians were between 18.6 and 20.9⁰ C, ensuring a good environment for the formation of SOAs in the classrooms.

Relative humidity that ranges between 40–70% can supply good conditions for indoor SOA formations.(2) In the assessed classrooms, relative humidity ranged between 57 - 70% in S1 and between 57 - 70% in S2, ensuring great physical conditions for secondary pollutants formation.

CONCLUSIONS

Indoor air quality and its association with impact over children's health are very important to study. There are several indoor sources for a significant amount of pollutants, emissions after cleaning products use being more and more studied nowadays. Environmental parameters including ventilation rate, temperature and relative humidity have significant influences on the formation of secondary organic aerosols reactions between BVOC emissions from floor cleaner and ozone. In the Romanian schools that took part of this experimental study, these also called comfort parameters, reach levels that supply good conditions for their formation.

Daily and weekly dry cleaning procedures (sweeping or dusting the surface) were predominant in both schools. Mopping the floors was the only main cleaning activity that used water and chemical solutions.

Cleaning activities in both schools were not efficient for maintaining a good air quality inside the classrooms because dry cleaning just disperses particles into the air. Vacuuming or the use of spray-polish could diminish this dispersion phenomenon. Also, guidance regarding the use of cleaning and disinfection substances should be given in schools, since there is evidence that their use can harm children's health and the classrooms environment ensure good conditions for substance emissions and formation of secondary pollutants.

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