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After-effects of Covid-19 Disinfectants and Antiseptics on the Public Health and Ecology in Metropolitan Lagos: Sustainability and Biophysical-Environment Based Approaches

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Abstract— The disinfectants used to control COVID-19 spread are chemicals, which may have human health and ecological implications. This study aimed to analyze the after-effects of the environmental cycling of three COVID-19 disinfectants and antiseptics, namely, Dettol®, Savlon® and Jik® on the public health and ecology in Lagos using laboratory-analysis, and simulated disinfectant applications methodologies. The results showed that the volatile matter of dilute Dettol, dilute Savlon and dilute Jik Bleach were 93.3%, 98.7% and 92.4% respectively, whereas the corresponding non-volatile matter were 6.70%, 1.25% and 7.60% respectively. The results of emission determinations showed that the office background total volatile organic compounds (TVOC) concentration under air conditioner (AC) ventilation was 174.5±23.1 ppb. When Dettol and Savlon were applied, TVOC increased to 738.6±393.5 and 258.7±99.7 ppb respectively, whereas it was stable at approximately 174.1±13.4 ppb when Jik was applied. The office background TVOC concentration under wind ventilation was 190.1±27.5 ppb, while the office TVOC level increased to 272.2±101.7 and 229.0±69.1 ppb when Dettol and Savlon were applied respectively and decreased to 151.0±6.3 ppb when Jik was applied. Additionally, the office background NO2 concentration under wind ventilation was 32.6±8.0 μg/m3, while the office NO2 level increased to 46.1±17.7, 105.0±199.8 and 58.5±18.7 μg/m3 when Dettol, Savlon and Jik were applied respectively. The office background HCl concentration was 272.1±142.7 μg/m3 under AC ventilation. The office HCl concentration increased to 355.8±209.9, 296.4±182.9 and 542.9±191.9 μg/m3 when Dettol, Savlon and Jik were applied respectively under AC ventilation. The office background HCl level under wind ventilation was 208.4±50.3 μg/m3, while the office HCl level increased to 318.6±112.6, 539.1±157.8 and 439.3±236.2 μg/m3 when Dettol, Savlon and Jik were applied respectively. The results of the volatile matter due to the disinfectant organic ingredients and the non-volatile matter suggested that the consumption of disinfectants and antiseptics in Lagos could translate to emission of volatile matter to the atmosphere, and salts to the soil and surface waters, expanding the environmental burden of the disinfectant pollutants. The simulated disinfectant applications results showed that significantly high total volatile organic compounds levels were emitted following Dettol application and this was a potential health risk to individuals susceptible to disinfectant vapours and sustainable environment practices. Also, the emitted HCl gas was significantly high from Savlon and Jik applications and would be important for people susceptible to Toxicant-Induced Loss of Tolerance.

Index Terms— After-effects, Covid-19 Disinfectants, ecology, hydrogen chloride, human health, nitrogen dioxide, risks, sustainability, volatile compounds,

1 INTRODUCTION

The pandemic status of COVID-19 across the globe requires social and community environmental hygiene to curb the transmission of the disease [1]. To this end, disinfectants and antiseptics have been extensively utilized. Antiseptics are antimicrobial substances applied to living tissue or skin to reduce the possibility of infection, sepsis, or putrefaction while disinfectants are antimicrobial substances applied to non-living objects to destroy microorganisms [2]. Some antiseptics are true germicides, capable of killing microbes, whereas others are bacteriostats and only capable of preventing their growth. The disinfectants and antiseptics used in the prevention and control of COVID-19 are chemicals, which may have human health and ecological consequences [3], thus the need for their sustainable consumption and production.

The ecotoxicity and human toxicity of a chemical are dictated by its physical and (bio)chemical properties such as solubility (bioaccumulation in fat), biodegradability, reactivity to biomolecules and permissible exposure limits, while human safety is related to its stability (reactivity to materials) and flammability which also depends on flash and boiling points and vapour density of the chemical. Similarly, solubility, vapour pressure, evaporation rate and octanol/water coefficient determine whether a disinfectant applied to a surface will be dispersed and transported through the air, water and soil environments, causing contamination [4].

A number of chemicals including disinfectants, antiseptics and sanitizers are toxicants, and at a critical ambient concentration, they can make susceptible people intolerant or disabled when exposed to them. The health hazards or Toxicant-Induced Loss of Tolerance (TILT) caused by a rare or less common toxicant could be mediated by other commonplace chemicals, termed triggers, thereby, making TILT a two-step illness process [5]. A major exposure or a sequence of low-level exposures to a relatively less encountered chemical by a susceptible person, which leads

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to loss of natural tolerance to the chemical, initiates the disease. The initiation makes the affected person sensitive and when they are exposed to triggers such as common, previously tolerated chemicals, foods, and drugs which have never made them ill, they experience symptoms [6]. Toxicants capable of initiating TILT include chemical spills, pesticides, cleaning agents, organic solvents, combustion products, drugs, and indoor air contaminants associated with materials used in construction. Sensitive persons show TILT symptoms which include allergy, difficulty with attention, memory and mood, gastrointestinal problems, migraines and headaches as well as fatigue and muscle pain [7].

Chan [8] reviewed the clinical features of seven human cases of deliberate oral exposure to Savlon (0.3% (w/v) chlorhexidine gluconate and 3.0% (w/v) cetrimide) admitted in a teaching hospital in Hong Kong from 1988 to 1991. The study reported that one patient who had taken Dettol simultaneously with Savlon presented with coma and hypotension complicated by adult respiratory distress syndrome, while the other six presented with milder symptoms such as vomiting, sore throat, nausea and abdominal pain. The report added that there were previously established adverse effects such as contact dermatitis, contact urticaria, keratopathy and anaphylactic shock following chlorhexidine gluconate use.

Mehtar et al. [9] reported the clinical impacts of deliberate human spray with 0.5 % chlorine during the Ebola infection fight in West Africa. The cross-sectional interview enrolled 1,550 Ebola survivors, healthcare workers and quarantined non-clinical Ebola contacts and found that after one exposure to chlorine spray, there was an increase in the number of eye symptoms in the three groups and a statistically significant increase in respiratory tract symptoms in the healthcare workers and Ebola survivors. Following multiple exposures, respiratory and skin symptoms escalated significantly. The adverse eye, skin and respiratory effects significantly rose from single to multiple exposure for healthcare workers. The study further added that the use of personal protective equipment did not prevent the adverse effects of chlorine exposure. Given the odds ratio of 2.4 to 3.3 obtained, chlorine spray could cause adverse health effects twice to thrice in the exposed population more than the non-exposed population.

Tripathy et al. [10] reported some toxicological properties of dilute Savlon, composed of 0.5% (w/v) cetrimide and 0.05% (w/v) chlorhexidine, which was always assumed as a safe scolicidal agent during surgical removal of hydatid cysts. The authors, however, stated that there was no recommended concentration or dosage of the product. The study explored the effects of the dilute Savlon on the pulmonary system and observed acute lung injury, respiratory distress, severe metabolic acidosis, renal failure and acute cardiopulmonary distress due to Savlon use during surgery of pulmonary hydatid cysts.

Samuel et al. [11] discussed that surgical fires are seldom but significant while using skin antiseptics and could result in a severe injury if not death of the patient. The study attributed surgical fires to vapour from alcohol-based skin preparations in the presence of elevated oxygen concentration and spark from an electric/thermal device. Spigelman and Swan [12] also recognized press reports of patients who caught fire or sustained chemical burns while using skin antiseptics in the operating theatre. They consequently reviewed the flammability risks of skin antiseptics such as povidine-iodine and alcohol-based solutions, and audited 10 operating theatres. They confirmed the risk of operating room fires from alcohol-based skin antiseptics but added that antiseptics in aqueous solutions only smouldered [12]. Their survey clarified that alcohol-based solutions were not used in the operating theatres but were used in anaesthetic bays for insertion of epidural and central line catheters.

Volatile organic compounds emitted into the atmosphere from disinfectants and antiseptics react with other pollutants e.g., NOx in the presence of sunlight to form ground-level ozone and particulate matter which are precursors of smog formation [13], leading to atmospheric pollution. Besides health hazards, safety hazards also have been observed from the application of antiseptics. Surgical fires have been documented to arise from alcohol-based skin preparations applied prior to surgical operation with attendant burns on patients and safety risks to workers [11].

The high incidence of COVID-19 cases in Lagos, Nigeria has necessitated the disinfection of social and physical environments including roads, bus stops and terminals, motor parks, infected people's homes, institutional premises, baggage at airports to control the disease [14], [15]. This may have encouraged higher industrial production of the disinfectants and increased industrial effluents and raised the environmental burden. The increasing public and domestic use of disinfectants and antiseptics would likely generate high levels of wind-dispersed disinfectant vapour emissions which may create environmental public health hazards as well as runoff of stormwater-mobilized disinfectants to natural waterbodies, resulting in possible degradation of aquatic ecosystems.

In Lagos, however, liquid effluents from homes, public institutions, offices and markets are not treated, disposed of in drains and allowed to flow through open or closed drains to link natural waterbodies [16]. The rise in the use of disinfectants is likely to add to the load of organic and inorganic pollutants ending in Lagos surface waters, air, and soils. This also may increase human exposure to the volatile compounds vapourizing from the disinfectants. This study aimed to consider the sustainability and bio-physical environment concepts in investigating the impacts of the environmental cycling of COVID-19 disinfectants and antiseptics on the public health and ecology in Metropolitan Lagos. Determination of disinfectant-derived emissions in simulated applications was carried out in a typical office and a typical outdoor environment in order to arrive at human exposure levels.

We hypothesized that consumption of disinfectants and antiseptics would raise the human exposure to vapours of the products and expand the environmental burden. We also hypothesized that the production and consumption of the disinfectants and antiseptics would not be sustainable in Lagos, Nigeria.

2 METHODOLOGY

2.1 Disinfectant and Antiseptic Sample Collection

Three disinfectants/antiseptic liquids, which were frequently used in Lagos and whose ingredients were among those recommended by the US Environmental Protection Agency [17] for fighting SARS-CoV-2, were obtained in duplicate from three different markets in Lagos for the study. The samples were Savlon® Antiseptic Liquid (Johnson and Johnson) composed of 0.3% (w/v) chlorhexidine gluconate and 3.0% (w/v) cetrimide (as active ingredients), and 2.84% (w/v) n-propyl alcohol (as excipient); Jik® Household Bleach (Reckitt-Benckiser) composed of sodium hypochlorite (as active ingredient), and fragrance and water (as excipients); Dettol® Antiseptic Disinfectant (Reckitt-Benckiser) composed of 4.8% (w/v) chloroxylenol, 8.38% (w/w) pine oil and 9.43% (w/w) isopropyl alcohol (as active ingredients), and 5.6% (w/w) vegetable soap, saccharum ustum q.s. and water (as excipients).

2.2 Analytical Procedures

2.2.1 Procedures for disinfectants and antiseptics analyses

The determination of pH, volatile matter and non-volatile matter were carried out on dilute disinfectant samples prepared from each of the disinfectant/antiseptic products. This simulated the disinfectant aqueous solution preparations instructed by the product manufacturers. The dilute sample was made by adding a measured volume of the liquid product to a measured volume of distilled water according to the instructions for use on the product labels as follows: 13.7 mL Dettol to 270 mL distilled water; 125 mL Jik to 5 L distilled water; 60 mL Savlon to 1 L distilled water. After sufficient stirring, the pH of the samples was carried out by potentiometric method using a pH meter (Mettler Toledo S220). Volatile matter was determined according to ASTM D2369 Method [18]. Aluminum foil dish was weighed using an analytical balance and 3.0 mL of distilled water (solvent) was added to it. The sample was added dropwise from a 1-mL syringe into the foil dish until a sample size of 0.5 g was weighed. The dish was swirled to disperse the sample. The sample was allowed to stand for at least 1 h before oven drying. The sample was subsequently dried in the forced draft oven (Genlab MINO/50) for 60 min at 110 ^{o}C. The sample was removed from the oven, cooled in a desiccator to ambient temperature and reweighed. The determination was carried out in duplicate. The percent non-volatile matter was estimated as the difference between 100% and the percent volatile matter [18].

2.2.2 Emission determination procedures for the simulated applications

Total volatile organic compounds (TVOC), hydrogen chloride gas (HCl) and nitrogen dioxide (NO_2) emitted during and after the application of each disinfectant were determined in August, 2020 at about 3:00 p.m. in a typical office (43.31 m^2 in area) and on a typical outdoor floor (16.00 m^2 in area). Two experimental determinations were carried out in the office; one was when the office was ventilated with air conditioner (AC ventilation), the second was when the office was ventilated with opened windows for local winds movement (wind effect ventilation) and the air conditioner was powered off. The AC ventilation condition was to simulate the typical concentrations of the disinfectant-derived emissions to which people are exposed inside banks, corporate and institutional offices with AC, while the wind ventilation was to simulate the pollutant concentrations which people encounter in hospital wards and administrative offices without AC, in 41-seater buses and their ticketing booths, in train coaches and train station offices without AC. The outdoor floor determination was to simulate the typical emission concentrations to which people are exposed in the open air at hospitals, train stations, 41-seater bus rapid transport (BRT) terminals, and airports in Lagos.

For the office determinations, the recommended dilute disinfectant solution was applied sufficiently with a wipe on an office desk (1.44m^2 in area) until complete coverage. For the outdoor concreted floor, the solution was applied with a mop on the floor until complete coverage. As the disinfectant application started, previously calibrated Advanced Sense Pro® meter (GrayWolf Sensing Solutions, USA) was simultaneously held at 4 feet above the ground for 30 min (and readings were taken at 3 min intervals) following source emission collection protocol by Oakes et al. [19]. The meter was equipped with Toxic Gas TG-501 Probe and Indoor Air IQ-610 Quality Probe for determining HCl, NO_2 and TVOC. The background (ambient) TVOC, HCl and NO_2 were measured prior to each application. Time-weighted average exposure was calculated as the sum of products (of emission concentration and 3-minute interval) divided by the 30-minute period.

3 RESULTS AND DISCUSSION

3.1 Results of Disinfectants and Antiseptics Analysis

The physico-chemical analyses showed that dilute Dettol, dilute Savlon and dilute Jik Bleach solutions had pH values of 9.01, 8.75 and 4.38 respectively. On post hoc multiple comparison of the pH values of the disinfectant solutions with the mean pH (7.81) of nine surface waters in Lagos [16], they were found to be significantly different ($p < 0.05$) (Table 1). The ecological implication of this is that continual discharge of the disinfectant aqueous solution effluent to the natural soil and water environments could influence the environmental pH value and affect the biota. The volatile matter of dilute Dettol, dilute Savlon and dilute Jik Bleach were 93.3%, 98.7% and 92.4% respectively while the corresponding non-volatile matter were 6.70%, 1.25% and 7.60% respectively.

It should be noted that the volatile matter determination

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was performed on dilute aqueous disinfectant solutions to simulate the actual pollutant contribution to the biophysical environment. Thus, the ratio of water to disinfectant in the composition of the volatile matter was 17:1 – 40:1 indicating

TABLE 1
RESULTS OF PHYSICO-CHEMICAL ANALYSES OF THE DISINFECTANTS AND ANTISEPTICS

Disinfectant or antiseptic formulation	pH level	Lagos surface waters' pH levels[a]	Statistical mean difference ($p \leq 0.05$)	Volatile matter %	Non-volatile matter %
Dettol aqueous solution	9.01 ± 0.053	7.81 ± 0.370	0.021	93.3 ± 0.535	6.70 ± 0.535
Savlon aqueous solution	8.75 ± 0.086	7.81 ± 0.370	0.038	98.7 ± 0.223	1.25 ± 0.223
Jik aqueous solution	4.38 ± 0.070	7.81 ± 0.370	0.001	92.4 ± 0.908	7.60 ± 0.908

n = 4 measurements (2 samples x duplicate analysis)

[a][16]

that approximately 2.31 – 5.81 % was the volatile matter due to the disinfectant organic ingredients. The non-volatile matter (1.25 – 7.60%) could have originated from the disinfectant inorganic ingredients or salts suggesting that the disinfectants, when applied to a surface, would leave a non-volatile residue behind after drying. The consumption of disinfectants and antiseptics in Lagos would translate to discharges of volatile matter to the atmosphere and salts to the soil and surface waters by the foregoing empirical results. Atmospheric pollutants have been established to finally deposit on ambient surfaces including lands and surface waters [20]. Thus, the consumption of the disinfectants has been demonstrated by this study to expand the environmental burden of the disinfectant emissions and effluents.

3.2 Results of Emission Determinations for the Simulated Disinfectant Application to Typical Environments

The results of emission determinations showed that the office background TVOC concentration under AC ventilation was 174.5 ± 23.1 ppb. The office TVOC concentrations when Dettol and Savlon were applied under AC ventilation increased to 738.6 ± 393.5 and 258.7 ± 99.7 ppb respectively whereas it was stable at approximately 174.1 ± 13.4 ppb when Jik was applied under AC ventilation (Fig. 1). The office background TVOC concentration under wind ventilation was 190.1 ± 27.5 ppb. However, the office TVOC level increased to 272.2 ± 101.7 and 229.0 ± 69.1 ppb when Dettol and Savlon were applied respectively and decreased to 151.0 ± 6.3 ppb when Jik was applied under wind ventilation. The outdoor background TVOC concentration was 201.1 ± 41.8 ppb. However, the outdoor TVOC level was stable at 217.5 ± 56.5, 204.0 ± 28.1 and 152.3 ± 7.9 ppb when Dettol, Savlon and Jik were applied respectively to the outdoor floor. In addition, the office background NO_2 concentration under AC ventilation was 57.1 ± 26.0 $\mu g/m^3$. The office NO_2 concentration when Dettol, Savlon and Jik were applied under AC ventilation changed to 70.8 ± 32.2, 70.7 ± 41.6 and 49.2 ± 18.4 $\mu g/m^3$ respectively (Fig. 1). The office background NO_2 concentration under wind ventilation was 32.6 ± 8.0 $\mu g/m^3$ but the office NO_2 level increased to 46.1 ± 17.7, 105.0 ± 199.8 and 58.5 ± 18.7 $\mu g/m^3$ when Dettol, Savlon and Jik were applied respectively under wind ventilation. The outdoor background NO_2 concentration was 53.6 ± 21.9 $\mu g/m^3$. However, the outdoor NO2 level was stable at 54.0 ± 25.9, 53.5 ± 29.5 and 43.5 ± 21.4 $\mu g/m^3$ when Dettol, Savlon and Jik were applied respectively to the outdoor floor.

Further results showed that the office background HCl concentration was 272.1 ± 142.7 $\mu g/m^3$ under AC ventilation. The office HCl concentration increased to 355.8 ± 209.9, 296.4 ± 182.9 and 542.9 ± 191.9 $\mu g/m^3$ when Dettol, Savlon and Jik were applied respectively under AC ventilation (Fig. 1). The office background HCl level under wind ventilation was 208.4 ± 50.3 μg/m3. However, the office HCl level increased to 318.6 ± 112.6, 539.1 ± 157.8 and 439.3 ± 236.2 $\mu g/m^3$ when Dettol, Savlon and Jik were applied respectively under wind ventilation. The outdoor background HCl concentration was 348.8 ± 92.1 $\mu g/m^3$ but the outdoor HCl level increased to 431.6 ± 172.1, 385.3 ± 144.2 and 521.1 ± 218.3 $\mu g/m^3$ when Dettol, Savlon and Jik were applied respectively to the outdoor floor.

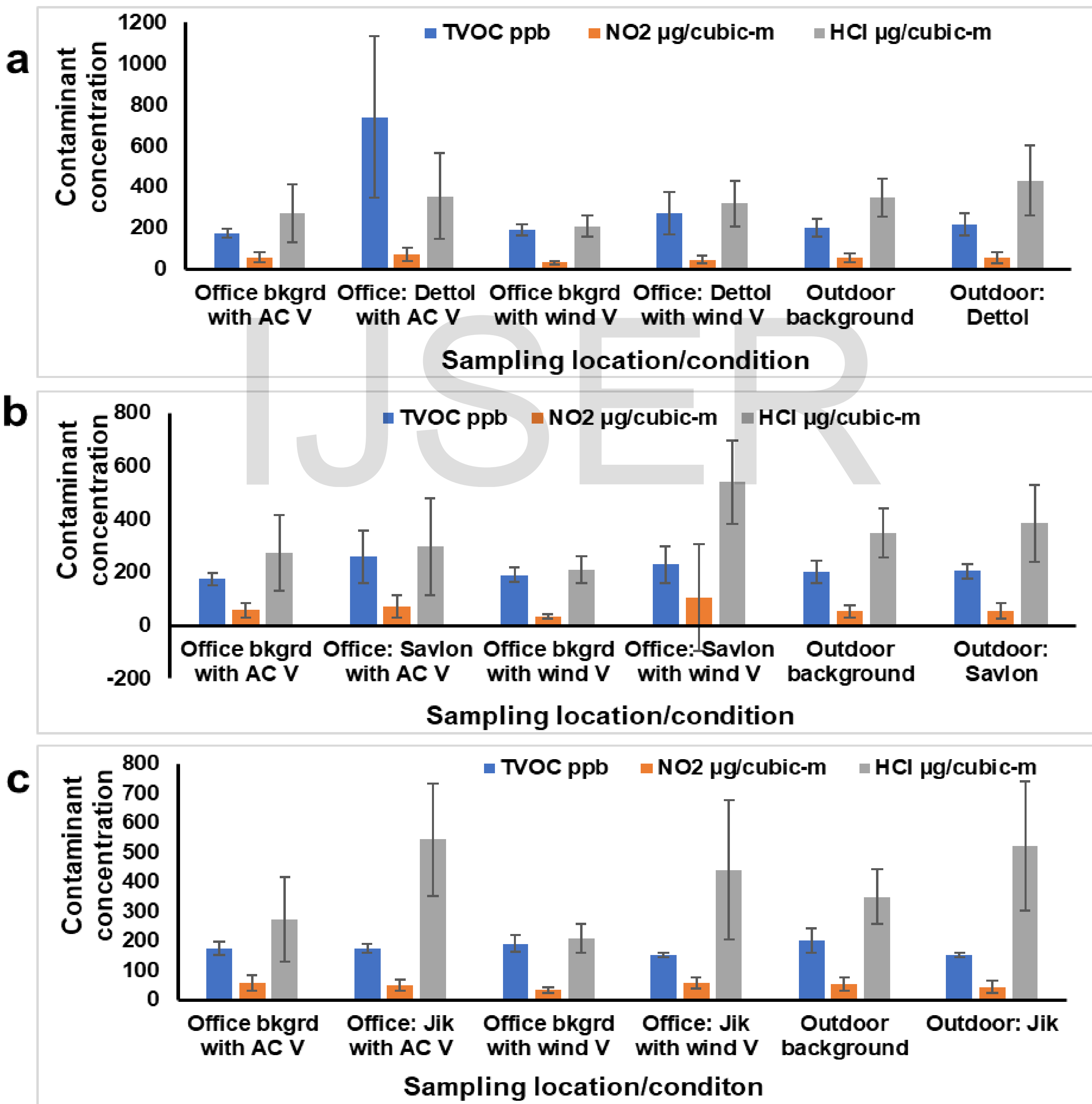

Fig. 1. The background (ambient) air quality and the contaminated air quality following the application of each disinfectant or antiseptic. **a)**. Emissions from Dettol application. **b)**. Emissions from Savlon application. **c)**. Emissions from Jik application. bkgrd– background; AC– air conditioner; V– ventilation; NO2– nitrogen dioxide.

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Repeated-measures analysis of variance (ANOVA) was used to determine the effects of the three experimental settings (indoor office with AC ventilation, indoor office with wind ventilation, and outdoor environment) and the effects of the three disinfectant formulations (background, Dettol, Savlon and Jik) on the air emissions of TVOC, NO_2 and HCl. Experimental settings (location/condition) was the within-subjects factor, disinfectant formulations was the between-subjects factor, and TVOC, NO_2 and HCl were the measures. The ANOVA results showed that the different disinfectant formulations produced significantly different air concentrations of TVOC ($F = 15.6, df1 = 3, df2 = 36, p = 0.000$) and HCl ($F = 5.48, df1 = 3, df2 = 36, p = 0.003$) contaminants while there was no significant effect for NO_2 ($F = 0.938, df1 = 3, df2 = 36, p > 0.050$). Post hoc multiple comparison showed that the emitted TVOC was significantly different from the background level when Dettol ($p = 0.012$, positive) and Jik ($p = 0.009$, negative) were applied while the TVOC emission was not significant (p =0.090) for Savlon application. Further post hoc comparison showed that the emitted HCl gas was significantly different from the background level when Savlon ($p = 0.048$, positive) and Jik ($p = 0.004$, positive) were applied while the HCl emission was not significantly different ($p = 0.331$) for Dettol application.

The ANOVA results also showed that the different experimental settings elicited significantly different air concentrations of TVOC ($F = 21.5, df = 2, p = 0.000$), whereas there were non-significant effects for NO_2 ($F = 0.434, df = 2, p > 0.050$) and HCl ($F = 1.87, df = 2, p > 0.050$) contaminants for the disinfectant application. This is in agreement with Fig. 1 where the emitted TVOC concentrations derived from the disinfectants applied to the office were generally higher than those observed for the outdoor environment. This was because of the enclosed nature of the office which partially confined the emissions within the walls leading to relatively high concentrations in the office. Fig. 1 shows that emissions derived from the disinfectants applied to the outdoor environments were minimal and not substantially different from the background ambient concentrations. This was due to free wind movement which would have allowed local turbulence and/ ground-based convective currents to promote the diffusion of the emissions [20]. A more important factor promoting pollutant diffusion is the interplay of lapse rate – air temperature fall with altitude. From afternoon to mid-night, environmental lapse rate (actual rate) is likely greater than dry adiabatic lapse rate (theoretical rate), or the air is unstable in most locations which allow injection of the emission into the upper, free troposphere [21]. This, in turn, could have enabled the emissions to undergo long-range transport, thus diffusion and lowering of the emitted material concentration occurred since the emission determination in this study was performed from about 3:00 p.m. till evening.

Dettol MSDS supplied exposure control limits (stated in Table 2) to ensure personal protection against adverse effects of the product use. In this regard, the MSDS cited two predominant United States' agencies, ACGIH (American Conference of Governmental Industrial Hygienists) and OSHA (Occupational Safety and Health Administration, 2012), regulating occupational exposure to hazardous materials. The maximum TVOC exposure which a typical cleaner or employee could encounter in Lagos is 151.0 – 738.6 ppb according to this study (Table 2). Comparing this exposure level with the relatively high regulatory exposure control limits of about 5,000 – 400,000 ppb [22] in Table 2, it appears that there is no risk possible from the exposures to Dettol, Savlon and Jik. However, recurring low-level exposure through inhalation over a long period could make susceptible persons sensitive or lose their natural tolerance to normally tolerated chemicals [7], thus, the initiation of TILT disease.

TABLE 2

OBSERVED TVOC EXPOSURES (30-MINUTE TIME-WEIGHTED AVERAGE) FOLLOWING DISINFECTANT APPLICATION

Sampling location/condition	TVOC exposure ppb		
	Dettol application	Savlon application	Jik application
Office with AC ventilation	738.6	258.7	174.1
Office with wind ventilation	272.2	229.0	151.0
Outdoor environment	217.5	204.0	152.3
ACGIH-TLV	Chloroxylenol: LC_{50}: 6,290 µg/L/4h rat Isopropanol: TWA: 200,000 STEL: 400,000 Pine oil mist: 5,000 µg/m^3 [22]	Not available	Not available
OSHA-PEL	Isopropanol: TWA: 400,000 [22]	Not available	Not available

TLV- threshold limit value: occupational exposure limit established by the ACGIH. STEL-short-term exposure limit: maximum concentration for a continuous 15-minute exposure period. TWA-time weighted average: the concentration to which someone is exposed, averaged over the total time of exposure (work hours 8 to 12 hours). PEL- permissible exposure limit: legally binding occupational exposure limit stipulated by OSHA and normally measured as an eight-hour time-weighted average.

3.3 Health and Safety Risks of Disinfectants and Antiseptics

Manufacturers of disinfectants and antiseptics have followed the national health and safety regulations by providing their product material safety data sheets (MSDS) on request. The MSDS for Dettol [22] was compliant with the Hazardous Materials Identification System (HMIS), the NFPA 704 Code (National Fire Protection Association) [23] and the OSHA Hazard Communication Standard HCS 2012 [24]. The MSDS showed that Dettol does not cause chronic health problems and the acute health problems it could elicit are moderate (HMIS rating 2). This implies that on a prolonged or continuous exposure, Dettol could cause temporary incapacitation or injury such as central nervous system (CNS) effects unless a remedial or medical action is taken to avert it. Temporary CNS effects include nausea, dizziness, headache, and fatigue. Also, Dettol or any HMIS health rating 2 chemical is moderately sensitizing or irritating to target organs such as eyes, skin and respiratory system and could cause reversible eye injury persisting for more than seven days.

Furthermore, Dettol MSDS [22] showed that the product could cause a serious flammability hazard (HMIS/NFPA rating 3). This identifies Dettol as a liquid which could be ignited under almost all ambient temperatures; this is primarily due to its isopropyl alcohol constituent. The flash point for Dettol is 104 ^{o}F (40 ^{o}C) and other physical properties such as octanol/water coefficient, vapour pressure and evaporation rate were not provided by the MSDS. Nevertheless, HMIS/NFPA flammability rating 3 presented Dettol as near a liquid having a flash point above 73 ^{o}F (22.8 ^{o}C) but below 100 ^{o}F (37.8 ^{o}C) and is thus, classified as a Class 1C flammable liquid [23]. The physical hazards rating of Dettol is minimal (HMIS/NFPA rating 0) according to the MSDS indicating that it is normally stable (not self-reactive) even under fire exposure conditions and is not reactive with other commonplace materials. By implication, Dettol is not reactive with air (pyrophoric), water, metals (corrosive) and is not oxidizing [4]. The personal protection index for Dettol is B indicating that users should wear safety glasses and hand gloves to ensure their safety and health.

Johnson and Johnson provided an old MSDS (1999 version) [25] for Savlon and it was not formatted to the standard numerical ratings and diamond system of NFPA 704 Code [23] and OSHA HCS [24]. However, it complied with the ISO 11014-1:1994 (by International Organization for Standardization) and the ANSI Z400.1:1996 (by American National Standards Institute). The MSDS showed that Savlon has minimal health effects. Hence, it is a chemical formulation that causes little or no significant health risk. It can be irritating to the skin, eyes, and oral path. Other hazard statements from the MSDS informed of risk of dermatitis and risk due to inhalation under excessive exposure. Savlon has no record of chronic effects. The Savlon MSDS further informed that the product is stable if stored under normal conditions. This implies that Savlon is unstable to reactive materials especially heat and oxidizers according to the definition of a stable material [23]. The personal protection statement for Savlon informed users to wear safety glasses. Unlike Dettol MSDS, several other important data e.g., flammability (or flash point) and physical hazards (stability) ratings and (occupational) exposure limits were not on the Savlon MSDS.

The MSDS for 4-6% sodium hypochlorite, the constituent of household bleach, was provided by Fisher Scientific [26]. The MSDS was complaint with the Commission Directive 2001/59/EC [27], NFPA-704 code [23] and OSHA HCS [24]. The MSDS informed that a household bleach is classified as Risk 31 meaning that on contact with acids, it can liberate a toxic gas. Also, it is classified as Risk 34 meaning that it can cause burns to the eye and skin. The hazard symbol (personal protection index) for bleach is C informing users to wear safety glasses, hand gloves and synthetic apron to ensure their safety and health during use [26]. The NFPA health hazard rating 2 for bleach signifies moderate toxicity. The implication is that, on prolonged exposure, it could cause brief breakdown, incapacitation, or injury unless remedial or medical action is taken. The CNS may be affected by the continuous exposure. The flammability hazard rating 0 indicates minimal hazard. This denotes that bleach will not burn when exposed to a temperature of 1500 oF (815.6 oC) for 5 minutes [23]. The NFPA reactivity hazard rating 0 for bleach signifies minimal hazard and is assigned to a chemical which is normally stable under fire exposure conditions (not pyrophoric) and not reactive with water.

3.4 Risks of Disinfectants and Antiseptics to Ecology

Dettol MSDS reported that components of the product have been identified as having potential environmental concerns. It demonstrated that ecotoxicty of isopropanol to freshwater algae, ecotoxicty of isopropanol and chloroxylenol to freshwater fish species, and ecotoxicty of isopropanol, chloroxylenol and pine oil to water flea have been established [22]. No data were provided by the MSDS concerning Dettol (bio)degradability/persistence and (bio)accumulation in the biophysical environment. However, chloroxylenol contains a carbon-chlorine bond which is a strong one and gives chlorinated organic compounds (e.g., organochlorines) their persistence [28]. Thus, they have come under the monitoring of the Stockholm Persistent Organic Pollutants Convention as compounds having a long-range transport or the ability to be found where they were not produced or applied [29].

4 CONCLUSION

The consumption of disinfectants and antiseptics would translate to increased discharges of volatile matter to Lagos atmosphere and salts (1.25–7.60%) to soil and surface waters based on the laboratory empirical results. This, therefore, would increase the environmental burden of the disinfectant emissions and effluents. The sustained effluent discharge potentially could cause ecotoxicity to the soil and water biota based on the empirical physico-chemical data and ecotoxicity review data presented here. The increased consumption of the chemicals potentially could raise the human exposure to vapours of the chemicals which would determine their personal protection and sustainable environment practices.

The significantly high TVOC levels emitted following Dettol simulated applications were a potential health risk to individuals susceptible to disinfectant vapours. Also, the emitted HCl gas was significantly high from Savlon and Jik simulated applications and would be important for people susceptible to Toxicant-Induced Loss of Tolerance.

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