Experimental Measurements for Ozone Output Characterization in Material Treatment

A. Lay-Ekuakille, P. Vergallo, G. Griffo and V. Pelillo
Department of Innovation Engineering, University of Salento, 73100 Lecce, Italy
Email: aime.lay.ekuakille@unisalento.it

***Abstract*—The dry treatment of textile allows to reduce impacts of water treatment, by means of reagents, in the soil and subterranean matrixes. Ozone treatment to remove bacteria and microbes is very useful and it serves as alternative to other systems. There are concerns about residues of ozone in the internal and external atmosphere. In the first case, we deal with workers' protection and in the latter regards outside air pollution. The paper illustrates an experimental facility built for dry treatment of textiles by means of ozone and experimental measurements performed at the exhaust. An analytical characterization of samples of textiles has been done to obtain a confirmation of bacteria abatement.**

***Index Terms*—Air pollution, textile dry treatment, ozone generator, measurements.**

I. Introduction

The quality of effluents discharged in soil and sub-soil is a matter of great concerns. Conscientious rulers are producing new legislation for recovering contaminated waters avoiding their lost for a double reasons: saving water and preserving the environment. Surface water seeps through the soil and becomes groundwater. Conversely, groundwater can also feed surface water sources. Sources of surface water pollution are generally grouped into two categories based on their origin. Point sources refer to contaminants that sink a waterway from a single, identifiable source, such as a pipe or a ditch. Examples of sources in this category include discharges from sewage treatment plant, a factory or a city storm drain. Nonpoint source pollution refers to diffused contamination that does not originate from a single discrete source. The majority of water pollutants is eventually carried into the oceans by rivers. The influence can be traced hundred miles from the origin by studies using hydrology transport models.

More than one-third of Earth's accessible renewable freshwater is consumptively used for agricultural, industrial, and domestic purposes. As most of these activities lead to water contamination with diverse synthetic and natural chemicals, it comes as no surprise that chemical pollution of natural water has become a major public concern in almost all parts of the world. Particularly, our interest is on hydrocarbon pollution that can produce serious health disorders like respiratory diseases, heart diseases, cancer, and even death. Hydrocarbon pollution may be analyzed by several categories of methods: physical, chemical, and biological. Many involve collection of samples, followed by specialized analytical tests. Fig.1 depicts

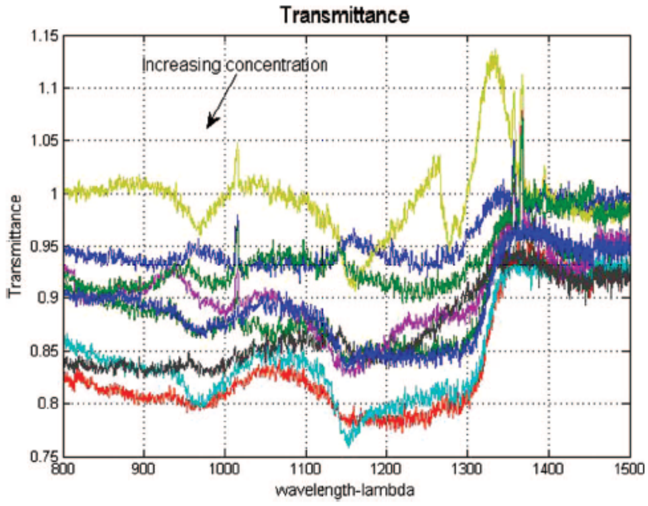

FIG. 8. Transmittance profiles for different sample concentration.

Fig. 1. Values of transmittance vs wavelength of surface waters discharged in sub-soil [1].

the quality determination of discharged water for protecting subterranean waters.

As we have seen previously air pollution is plays a key role in both evaluation indoor and outdoor configuration. The question of indoor configuration regards workers and must be faced as it is done in hospital facilities, in particular for surgery rooms. Further elements to be taken into account are the concentration of CO_2 and sevoflurane [2] which can be considered as an indirect index of environmental pollution. National and European rules often encompass the American NIOSH (National Institute for Occupational Safety and Health) regulations and maximum concentrations; for instance, N_2O=25 ppm for general surgery rooms, N_2O= 50 ppm for dental surgery rooms, and halogenated gases = 2 ppm as ceiling value. The above indoor pollutants are characterized generally by using photoacoustic system and chromatography [3]. The photoacoustic application was developed in the 1970s by Rosencwaig and Gersho [4]. Applying Beer's Law with radiation intensity I0 and optical absorption coefficient β:

Timer	Temp	Max humidity	Air flow rate	O_3
0-120'	5-40○C	70-80%	420m^3/h	10 gr/h

TABLE I
OZONE GENERATOR MAIN CHARACTERISTICS

$$dI = -\beta I dx \Longrightarrow I = I_0 e^{-\beta x} \quad (1)$$

Suppose the incident radiation is modulated with frequency ω. Then the incident intensity is given by:

$$I' = \frac{1}{2} I (1 - \cos \omega t) \quad (2)$$

Returning to the purposes of the work, it necessary to recall the importance and the effects of ozone on textiles. The use of disinfectants and chemicals is standard practice in various common clinical episodes. Many hospitals use formaldehyde vaporization, paracetic acide, or clororhexidine for this purpose; more recently, formulations of hydrogen peroxide have been advocated, although the extent to which these contribute to reduced infection transmission in hospitals remains unclear. Such methods have inherent drawbacks, including high cost, labor-intensiveness, and potential for inhalation of disinfectant vapors by hospital staff, formation of dirty flecks on glass surfaces, and retention of unpleasant disinfectant odor after decontamination. Ozone has well-documented bactericidal properties can be generated cheaply, and although toxic rapidly dissociates to oxygen. In addition, the release of ozone can be controlled from outside the room. Thus as a decontamination agent, gaseous ozone offers potential advantages over chlorine-releasing agents and other disinfectants. Subsequently, an indoor monitoring activity is required [5], [6].

II. FACILITY DESCRIPTION

The treatment room is located in a big hangar and its dimensions are 3mx3mx3m as shown in Fig.2. The main characteristics of the generator are illustrated in table I. the amount of ozone produced by the generator is 10 gr/h. The ozone generator used (Fig.3) in all tests was a portable module containing multiple corona discharge units, a circulating fan, and an efficient catalytic converter (ie, scrubber) to reconvert ozone to oxygen at the termination of ozone exposure. Its power is 100 W with 220 V for mains. All of the components were remote- controlled from outside the test room. Ozone concentration in the room was monitored continuously as well as outside. Some dedicated and reactive vials (Fig.4) along with a small pump (Fig.5) are used for the experiments.

The operating mode of the system is the following: 30 minutes of working, 30 minutes of pause, and door opening. During the 30 minutes of pause, doors are closed and the air extractors (extraction fans). 30 minutes are sufficient for removing bacteria from tissues since they are considered not hazardous because they come from home and specific recycling process. They could be normal clothes abandoned by people. After this process, tissues can be cut in small pieces for the use in industries for cleaning.

Fig. 2. Cabin

Fig. 3. Ozone generator

Fig. 4. Reactive vials

Fig. 4. Resistance vs concentration

III. Measurements and Preliminary Results

As it is known we must characterize external emissions from chimney and the indoor ones. For external emissions, since the quality of emissions can be reconducted to Gaussian modeling because of few hours of persistence in air and low concentration; this model considers a specific source of pollution placed at the origin of a point of reference (O_{xyz}) with an emission which is constantly equal to q and it is located within an atmospheric volume delimited by a closing surface. This model requires the presence of a vector wind with average velocity u and directional axis of the abscissa, and defines that the temporal variation of pollutant amounts C, is equal to the sum of pollutant quantity produced, plus the net quantity of pollutant that flows through the contour surface [7]:

$$\frac{\partial C}{dt} + u.\nabla C = -\nabla^2 q + E + R \tag{3}$$

where E is the instantaneous emission and R represents the chemical reaction of the pollution in the atmosphere. With a series of reductions and considerations, this equation can be simplified [8] to:

$$\frac{\partial C}{dt} = \frac{\partial C}{dx}\left(k_{xx}\frac{\partial C}{dx}\right) + \frac{\partial C}{dy}\left(k_{yy}\frac{\partial C}{dy}\right) + \frac{\partial C}{dz}\left(k_{zz}\frac{\partial C}{dz}\right) \tag{4}$$

(where [k_{jj}] is the tensor of scattering coefficient) and solved, obtaining the formula for the concentration:

$$C = \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}} exp\left(-\frac{1}{2}\left(\frac{y_r}{\sigma_y}\right)\right) exp\left(-\frac{1}{2}\left(\frac{h_e - z_r}{\sigma_z}\right)\right) \tag{5}$$

where Q is the total pollution emitted from a source placed at height h_e, and σ_y, σ_z are respectively lateral and vertical dispersion coefficients. The pollutant emission called plume is subject to a convective transport in the initial phase of the route, in which its centre of gravity settles at height h_m. Based upon emission consideration, the 7 vials, containing the gas captured by means of a small pump of Fig.4, have been analyzed and characterized by means of chemical instrumentation giving the values depicted in table II. Only a small amount of ozone has been detected but it does not represent a danger since it is very low with respect to Italian and European legislation [9].

NH_3	SO_2	H_2S	CO	NH_2	HC	O_3
0 μg/m^3	0 μg/m^3	0 μg/m^3	0 mg/m^3	0 μg/m^3	0 μg/m^3	<<120 μg/m^3

TABLE II
INDIRECT EMISSION CHARACTERIZATION FROM CHIMNEY

Fig. 5. Textile sampling

The indoor gas has been also analyzed [10], [11] and no abnormal values have been retrieved. The second round of analysis concerned the characterization of the a sample of tissue (Fig.5) closed in the cabin and under treatment. For that, in particular, the following parameters have been characterized with their results [12]:

- mesophilic aerobic content $< 10^6$/g
- faecal streptococci $<10^2$/g
- no salmonelle over 20 g

So the sample does not contain bacteria and we reaffirm that the treatment has cancelled and destroyed all eventual bacteria that were included in the textile.

Fig.6 illustrates the temperature distribution, on the ozone generator, just after the opening of the door. It also shows the low level of the temperature after the air extraction by means of the electrical fun included in the cabin. That is very important since the combination between high level of temperature and concentration of ozone is very dangerous for workers.

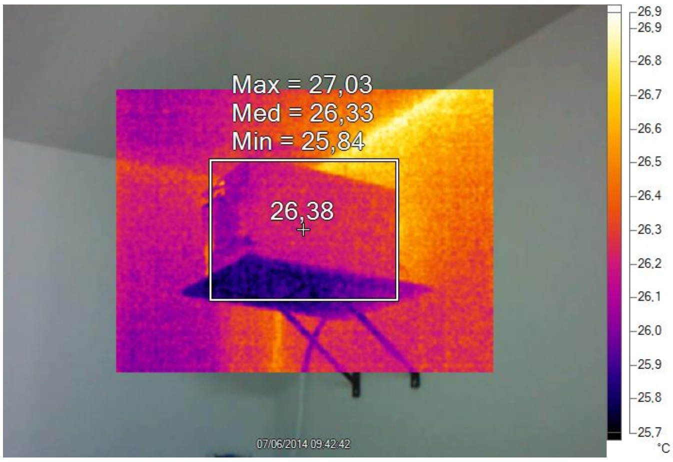

Fig. 6. Ozone vs temperature monitoring

IV. Conclusions

The paper has illustrated an experimental facility for treating textiles and clothes by means of ozone generator. Two kinds of characterization have been performed: outdoor and indoor characterization. The outdoor analysis is devoted to evaluate the quantity and the quality of emissions from the chimney, especially the residue of ozone. The indoor characterization is related to ozone from the cabin and the level of bacteria in the tissue. Both analysis have shown the optimal level of treatment delivered by the ozone generator.

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