UDC 624

A CONTRIBUTION IN AN EXPERIMENTALLY AND NUMERICALLY STUDY OF THE PARTICLES RE-SUSPENSION BY AN HUMAN ACTIVITY

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Introduction. Air pollution can be defined as a gas state or all of particles inside or outside buildings also of these concentrations pollution mostly can give impacts to a human health and quality of air surrounding. Since a few years, a quality of air interior has to be rise out as a subject worried into human sociality, politics, and the government's policy. Recently, this is very interesting topic as a simple observation in the urban lifestyle, an approximately is 80% of their activities were took inside rooms in their living housing, workplace, transportation, and other. Actually, for the numerous pollutants were gave significantly impacts for a quality of air interior in a building. This condition is quite same in last year ago, while a building envelope was increased and a ventilation rates were decreased to an improving in the economically energy using.

An air interior inside building is a deep complex for the characteristics of parameters gain that will give an impact on health and occupation comfort. There are multiple interactions between buildings, we used people who has live and work. It is like a condition of characteristic dynamic with any variability of pollution sources, also with the differences types of interior spaces, and condition of climate outside, also many types of ventilation. The pollution of inside and outside can be added as well, however it still correlated with other pollutants because it can be created such a volatile organic compound which presents in a general type of house.

On indoor air pollution, the main sources of contaminations for these occupants were on themselves and their activities, building materials such as wall coverings, paints and insulation materials also building equipments (appliances, ventilation system and air conditioning).

In many researches work have being started in order to a study of the quantified particles and their particles in the vertical walls, floors and ceiling ([1],[2],[3]). These studies have explained the re-suspension of particles radio-actives, marine sediment, etc; they have same subject in this research. However, a study for the particles re-suspension in home living without left other reason is almost empty. In fact, generally, in the activities indoor have a quite calming because it was not presented in the capability of an air current extraction in their particles grips.

According to Karlsson E [4], has described an experimental study that shows

the results for the particles re-suspension in a room. The results also explained a re-suspension is an important phenomenon and the rates of re-suspension have been given a rate, it is depending on a size of aerosol, human activity and floors.

Recently, based on work done by Fortain A [5], this subject was concerned in the characterisation of particle pollution in subway stations, in the other hand are shown that the re-suspension of particles in floors were given from passengers and platform ways. Therefore, this study also shown that according to the sizes of particles are predicted for the concentration particles can be unstable by a factor 2 to 10 is depending amount of passengers and platform ways during the timetable trains. Today, it is very limited study for a work done on the re-suspension particles in the ventilation air surrounding by human activities also knowledge's about these phenomena was remained nor a partial phenomenon [8].

We study propose to evaluate in the overall particles re-suspension from a floor as a simple activity by people, while this study we can impose of the boundary conditions but also the sources by a moving the environmental pollution. First of all, we have developed a protocol experimental based on previously studies of LaSIE ([1],[2],[7]) were explained an evidence of re-suspension in air ventilation. Thus, our experiments allowed us to make an identification of the different particles size such a re-suspension, which in usual already in the human activities conditions. Secondly, we have a different model; it is a model classic of Nazaroff et al [6], this model has been established for an electrical analogy model and we used this to provides a calculation prediction in the re-suspension also it can be allowed us to compare our measured value in our experimental.

Global classic modelling. A particle concentration indoor is depending on several parameters that why an air exchange with air outside, in generally these characteristics are shown by a rate of air renewal. As a same presence, an internal source of particle pollutant and the interactions with wall, namely as the rebound phenomena in re-suspension, is a greatly will give influence to the concentration of particles indoor [1,2]. A figure 1 as illustrated the different particularise exchange inside air surrounding.

We can calculus onto mass conservation for the particles pollutant in a mono-zone, which that can be expression with this relation:

$$\frac{dC_i}{dt} = f\lambda_r C_{ext} - \lambda_r C_i - \lambda_{de} C_i - \lambda_R C_{Di} + S_i , \qquad (1)$$

Where:

C_i : concentration input (kg or number m^{-3}),

C_{ext} : concentration output (kg or number m^{-3}),

C_{Di} : concentration of deposit particle (kg or number m^{-3})

S_i : source of particle input (kg or number $m^{-3}.s^{-1}$)

λ_r : coefficient of renewal air (s^{-1}),

fp : fraction penetrating, λ_{de} : parameter of deposit (s^{-1}), λ_R : parameter of re-suspension input (s^{-1})

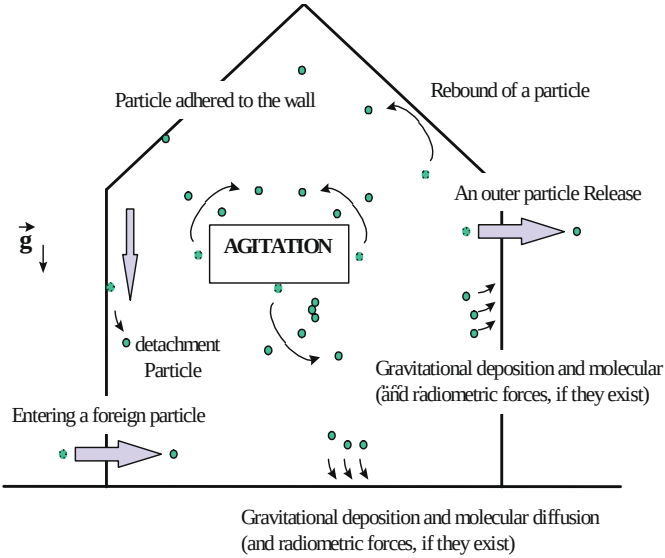


Figure 1. Particles movement in the wall surrounding

An electrical analogy modelling. The behaviour of a circuit coil might be allow to a regulation to the strength of current by checking the growth of a current in the various electronic devices. This capacity can be ‘’hold’’ or to inject the electrons in the electrical circuit, they brought us to consider the possibilities of assimilation in the cycles of load or discharged the electronic components in any phases re-suspension particles. Also we developed our model within an assimilating the behaviour particularises in a characteristic of RL circuit is following in this table:

Table 1

Analogical characteristics between particularises and electrics

Sizes of particularises	**Amount of electricity**
Concentration *c(t)*	Current *i(t)*
Coefficient input λ_d	$1/\tau$
C_0	E/R
Input	Force power
Re-suspension	Breezy power

For using this similarity, we find the formulas below:
Input:

$$C(t) = f(\Phi)\frac{E}{R}.e^{(A.t)} \qquad (2)$$

Re-suspension: $$C(t) = f(\Phi)\frac{E}{R}.(1-e^{(At)}) \quad (3)$$

It is important to be notify, which *f* is a function of particle diameter used, by the other hand function *f* can be use as a power in a polynomial with second degree. In particularly, this study case is an opposite use for a time constant in a RL circuit.

Devices and experimental protocol. Our experiments have been tested in a LaSIE laboratory ([7],[9],[10], see at figure 2), they are used the different floor materials (wood, smoothly linoleum, non-slip linoleum and carpet) that shown in a previously studies were considered in a well technically roughness was it made [10].

Figure 2.a. Room test in LaSIE

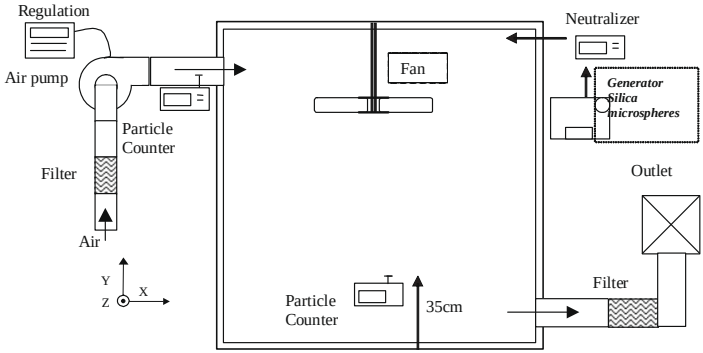


Figure 2.b. Schematic of the measurement chamber, aerosol particle generators and aerosol particle sampling

Also we have developed and implemented this protocol experimental based on a unit test with a relatively small volume [10], that was wooded a test unit, see in figure 2. Thus, we experimental has took in a room testing unit (2.5m x 1.5m x 2.5 m) with an installation system using a mechanical control ventilation (VMC) that has to adjust the debit flow and filter blowing of air compression.

This experimental study was installed onto floor of testing room, using 3 Grimm® particle counters (model 1.108). This is an according to a schematic of the measurement in figure 2 (aerosol particle generators and aerosol particle sampling). In addition, those particles were injected into a cell using TOPAS® ES 410 as an aerosol generator, also we used the neutralized electrostatic charges such a TOPAS® neutralizer EAN 581.

In figure 3a, 3b, 3c were illustrated in the major equipments are be using into differences of experimental studies, these equipments provided a neutralisation, generation and a counting device to inject the particles in the atmosphere also that includes the homogenisation for the pollutants mixing by a ceiling fan.

a) *b)* *c)*

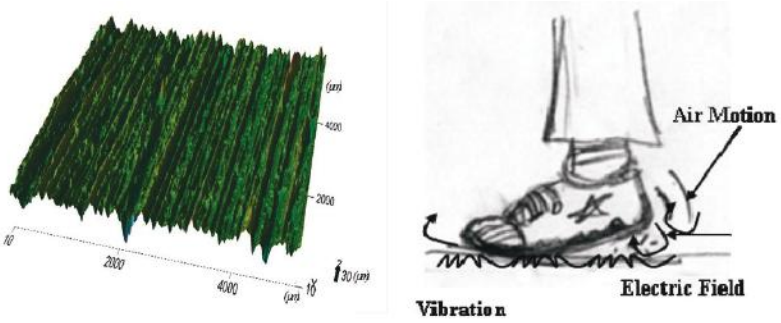
Figure 3.a.b.c: Particles neutraliser TOPAS EAN 581, Particles disperser TOPAS SAG 410, Laser Optical particles GRIMM 1.108

Besides that to have an evidence for the maximum results in re-suspension, VMC has added to make directly blown of filter air compression into interior cell also give a contribution for cleaning an air indoor that also to obliged the particles and to settled on the floor and wall (seem to figure 2b). So that, after to put down these particles, we stopped the VMC also air compressed were allowed into human witnesses it is always same in the work duration to 5 minutes which is an according to make marks and to determine within scrupulously respected.

The results. In this study, we only present the results for a coat of wood in the differences phases of particles behaviour such as deposition and re-suspension.

a) materials uses

We concerns on the 3D cartography of the coating wood (Floor, we used in contact directly with air ambient and physical properties by a person with a displacement. We offered in figure 4.a, it to be appreciate in the scrutinise relief, and figure 4.b, was illustrated an impact of person movement on the floor.



a) *b)*

Figure 4.a. Cartography model for wood structures, 4.b: Re-suspension by a human movement

b) Re-suspension

From the figure 5 and 6, we could be to identify for the numerical results with the experimental results (disability relative <10%). In this study experimental, we considered in the general model that will give a quite predictable result within a concerning of particles behaviour in a closed ventilation system. However, we could took for these numerical results with a small discontinuity in the transition input of re-suspension that shown in figure 7.

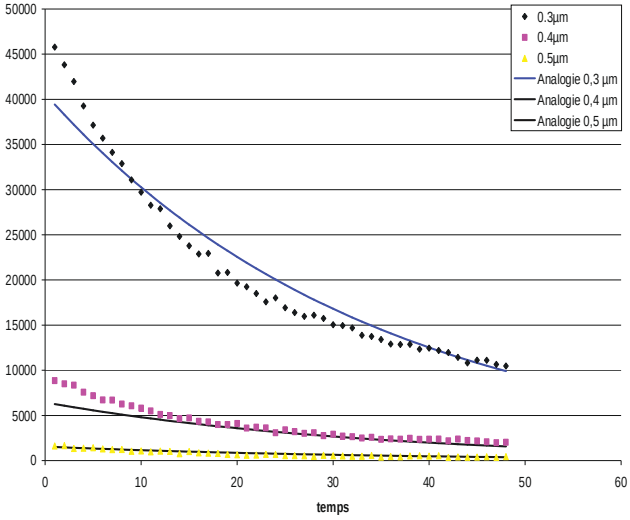


Figure 5 . Superposition des résultats expérimentaux / numériques (dépôt)

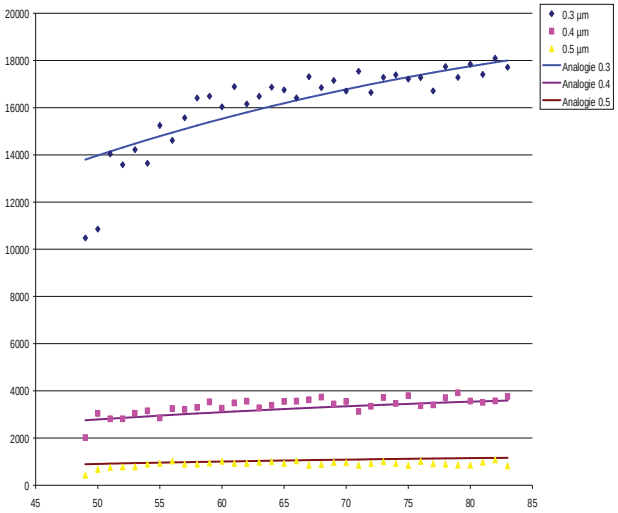


Figure 6 . Superposition des résultats expérimentaux / numériques (remise en suspension)

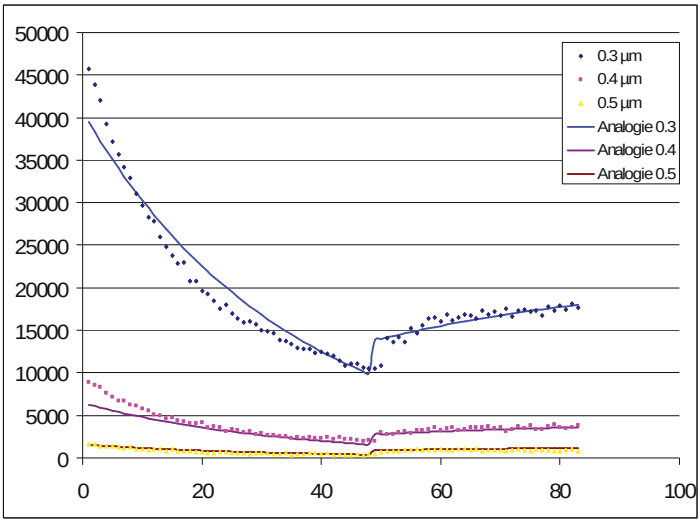


Figure 7 . Superposition des résultats numériques par analogie électrique

Conclusion and Recommendation

This study will give knowledge about the particles behaviour, in particularly to a downstream deposit (warehouse) onto internal of building surface. However, many parameters are given the models in a real form of particles behaviour also these parameters can be linked either to the particles or to the warehouse.

Also we propose in more advanced for the influences of materials hardness, especially in the particles re-suspension. Therefore, we have been developed this model and to be improved in a holding the effects of different forces in re-suspension such as mechanical forces (vibrations) and electrostatic dynamics [10].

REFERENCES

1. Abadie M. « Contribution à l'étude de la pollution particulaire : rôle des parois, rôle de la ventilation » Thèse Université de La Rochelle, LaSIE, Septembre 2000.
2. LIMAM K. « Transfert de Particules dans les ambiances ventilés » HDR Université de La Rochelle, LaSIE, Juin 2004.
3. LIMAM K. « Programme Interministériel pour une Meilleure Qualité de l'air à l'échelle locale et urbaine. Caractérisation physico-chimique et étude du transport des particules à l'intérieur des locaux» Projet National PRIMEQUAL2–MEDD– 2002/2007.
4. Karlsson E. et al. "resuspension of an indoor aerosol", National Defence Research Establishment, Department of NBC Defence, S-901 82 Umea Sweden, 1996
5. Fortain A. « Caractérisation des particules en gares souterraines » Thèse Université de La Rochelle, Leptab, Juin 2008.
6. Nazaroff **W**. W., Cass G. R. « Particle deposition from a natural convection flow onto a vertical isothermal flat plate » Journal of Aerosol Science 20, pp. 138-139, 1989.
7. Bouilly J. « Etude de l'impact de la pollution particulaire sur la qualité de l'air intérieur en site urbain» Thèse Université de La Rochelle, Leptab, Décembre 2003.
8. Gomes C. A. A., Hu B., Freihaut J. D. « Resuspension of allergen-containig particles under mechanical and aerodynamic forces from human walking. Intrudoction to an experimental methodology », Indoor Environment Center, Architectural department, University Park, PA 16802, USA, 2006.
9. El Hijri J., Draoui A., Limam K. « Etude expérimentale de la remise en suspension des particules. Comparaison entre des revêtements lisses et rugueux », 8ème Congrès de Mécanique, 17 – 20 Avril, El Jadida - Maroc, Volume II, pp. 346-348, 2007.
10. El Hijri J. «Contribution expérimentale et numérique a l'étude de la remise en suspension des particules par l'activité humaine», Thèse Université de La Rochelle, LaSIE, Décembre 2008.