Mansoura University
Faculty of Engineering
Mansoura Engineering Journal

PLANTS, SHADE AND SOLAR RADIATION EFFECT ON BIO-AEROSOL POLLUTION IN WASTEWATER TREATMENT PLANTS

(تأثيرات الطاقة الشمسية و النباتات والظل على التلوث بالهباء الحيوي في محطات معالجة مياه الصرف الصحي)

Soliman Saad Soliman Aborawash, *Muharram Fouad Abdu Allah El Din*, *Kamal El Hassanien Esmail Radwan* and Huda Fekry Mohammed El-Gamal

KEYWORDS:
Planting, bioaerosol, microorganisms, shading, WWTP, solar radiation.

الملخص العربي: *-تم تقدير تأثير كثافة الغطاء النباتي، التظليل والإشعاع الشمسي على مقدار التلوث بالهباء الحيوي لعدد من محطات معالجة مياه الصرف الصحي" WWTP" ، التي تعمل بنظام الحمأة المنشطة " ASP" ، حيث تم تقدير عدد مستعمرات الكائنات الحية المتكونة لكل متر مكعب من الهواء (CFU / M^3) تحت ظروف مختلفة من كثافة الغطاء النباتي، نسبة الظل والإشعاع الشمسي، كما تم الأخذ بعين الاعتبار المؤثرات الثانوية علي نسبة التلوث بالهباء الحيوي مثل مكان القياس واتجاه الرياح ودرجة الحرارة ووقت القياس. وقد وجد أن هناك علاقة مباشرة بين التلوث بالهباء الحيوي في الهواء وكثافة الغطاء النباتي ونسبة الظل. على العكس من ذلك،وجد انه هناك علاقة عكسية بين كل من الإشعاع الشمسي والتلوث بالهباء الحيوي. و على الرغم من ان وجود النباتات يرفع من جودة الهواء.إلا أنها تزيد من التلوث بالهباء الحيوي. أيضا وجود ظلال في محطات معالجة مياه الصرف الصحي وما حولها يزيد من التلوث بالهباء الحيوي*

Abstract— **Bioaerosol pollution was estimated in Waste Water Treatment Plants "WWTPs" working by Active Sludge Process "ASP". It was estimated inside and around the WWTPs, the factors effecting on bioaerosol pollution were evaluated. This paper focuses on planting density, shads and solar radiation amount as major effecting factors which effects on bioaerosol pollution. Other secondary parameters such as boundary condition, wind direction, temperature and measurement times were taken in consideration. The bioaerosol pollution in free air has been measured by CFU/M3. A direct relationship was found between bioaerosol pollution in air and both of planting density as same as shading ratio. Conversely, there was an inversely relationship between solar radiation and bioaerosol pollution. Despite the air quality is improved by plants, plants increase microorganism account in air. Also presence of shades in the WWTP and around it increases microorganisms account in air.**

Received: 14 August, 2018 - Revised: 14 October, 2018 - Accepted: 21 October, 2018

Soliman saad soliman aborawash, Researcher faculty of engineering Mansoura university ,

Muharram Fouad Abdu Allah El Din, Professors faculty of engineering Mansoura university ,

Kamal El Hassanien Esmail Radwan, Professors faculty of engineering Mansoura university ,

Huda Fekry Mohammed El-Gama, Professors faculty of engineering Mansoura university

1. INTRODUCTION

In WWTPs working with ASP, the aeration tanks emit microorganisms from its surface into the atmosphere as fine air-bubbles, these air-bubbles are converted to form bio-aerosol, contains bacteria, virus and fungi [1]. Fig.1 shows the bioaerosol that is generated above aeration tanks.

Bio-aerosol is carried by wind to distances, according to several factors like temperature, solar radiation, wind direction, wind speed and relative humidity. The ability of microorganisms to survive in air depends on their vulnerability to drying out. Many of staphylococci are resistant to drying out, and die out very slowly in the air, other kinds of bacteria can survive on clothes even 130 days, and 7 days on paper, and salmonella-typhi survive 10 days in dust, 97 days on clothes and 90 - 119 on a tree [2].

A huge number of humans, animals, and plants illnesses are caused by microorganisms present in fresh air.

Particular sources of microbiological air pollution are municipal facilities primarily wastewater treatment plants [3]. Some bacteria are agents of hypersensitivity, infection, acute toxic effects, allergies and cancer, respiratory

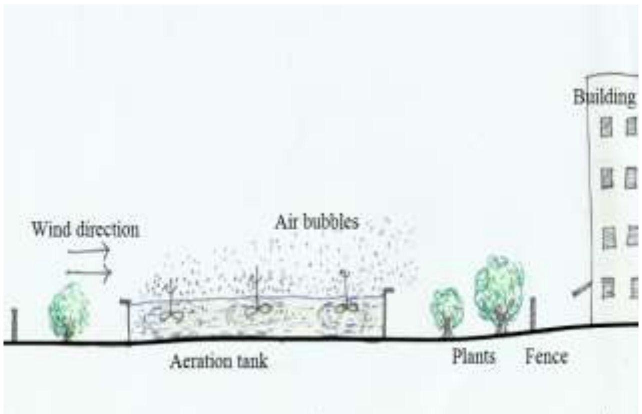

Fig.1 How the bio aerosol is generated by aeration tanks.

Symptoms and lung function impairment are the most widely [4]. Microorganisms have been recognized as a health hazard and associated with asthma severity, the risk of illness from environmental bacteria increases when they enter buildings in inappropriate numbers or multiply indoors [5].

The amount of CFU/M^3 in air reflects the bioaerosol pollution strength. According to the Commission of European Communities "CEC" maximum amount for an average elevated contamination is 2500 CFU /M^3, more than 2500 less than 10000 CFU /M^3 is a high contamination and more than 10000 CFU/M^3 is a very high contamination [6]. Also at distance of 250 m or at the nearest sensitive receptor "such as a dwelling or place of work", whichever is closer, to protect public health, the acceptable level for total bacteria is 1000 CFU /M^3 [7].

Generally many WWTPs are surrounded by plants, shades or buildings, minimize the solar radiation exposure. The research aims to measuring bioaerosol pollution by bioaerosol in WWTPs and find relationships between pollution by bioaerosol and each of plants, shades and solar radiation.

2 MATERIALS AND METHODS

The bioaerosol pollution has been estimated in various conditions, to find accurate scientific relationships between bioaerosol pollution and planting cover ratio, shading ratio, solar radiation conditions in Mansoura WWTP and Met-Mazah as well.

Planting Cover Ratio "PCR" has been estimated to reflect the total planting volume above the area around every sample point; PCR was estimated by the equation:

$$PCR = \frac{Vp}{A} \quad (1)$$

Where Vp is the total volume of plants above the surface area by cubic meters and A is the area of the land by square meters.

Shading Ratio "SR" also has been estimated to reflect the shade density around sample points; SR was estimated by the equation:

$$SR = \frac{As}{A} \quad (2)$$

Where as is the area of shaded land on surface, and A is the total area around the sample point. The samples were taken at various conditions of shading.

Solar radiation was measured by LUX meter above the Petri dish in every sample point to measure the solar radiation strength. The bioaerosol pollution was evaluated under several conditions of PCR and SR and solar radiation for two WWTPs, Mansoura WWTP and Meet-Mazah WWTP, these WWTPs are in Mansoura government "located in the east of Egyptian delta".

The bioaerosol pollution was collected by gravity Petri dishes and estimated by colony counting method. The "gravity Petri dish" has been in common use for qualitative bioaerosol measurements, where a dish of sterile medium is left open at the sampling site for periods of 1 to 10 min to investigate the cultivable bacterial or mould flora of the atmosphere [8]. The samples were collected in July 2015. The testing Petri dishes have been pre-prepared in the laboratory of faculty of science Mansoura University. The Petri dishes were left on surface level in every point for 10 minutes then were covered, collected and sent to the laboratory. Fig. 2 shows the Petri dishes at sampling time. In the laboratory the Petri dishes were preserved according to standards [9]. Then CFU/M^3 (Colony-Forming Unit per air Cubic meter) number was calculated for every Petri dish.

Fig. 2 Petri dishs at sampling time...

2.1 *STUDY AREA*

Mansoura WWTP has a capacity of 270000 m^3 /day. It receives domestic sewage and treats it using ASP. It is nearby Mansoura city surrounded by an agricultural area and scattered buildings used for residential purposes, Fig. 3 shows Mansoura WWTP location.

Fig. 3 Mansoura WWTP location.

Meet-Mazah WWTP is surrounded by an agricultural area, it is also working by ASP, and its capacity is 3000 M^3, its treatment ability is 1500 M^3/day. Fig. 4 shows Meet-Mazah WWTP location.

Fig. 4 Meet-Mazah WWTP Location

2.2 *Sampling design*

The Petri dishes were uniformly distributed inside several planted areas. The planting density for each area is estimated by PCR and four samples were taken for each estimated PCR. Table 1 shows PCR values and the numbers of samples.

TABLE. 1.
PCR VALUES AND THE NUMBERS OF SAMPLES

point description	PCR	Number of samples
no Plants	0	4
area with little plants	1.1	4
moderated planting area	2.2	4
full planting area	3.25	4

Other Petri dishes were distributed in deferent shading conditions were estimated by SR. The shaded area were measured and divided on the total area to reflect the shading ratio. Table 2 shows SR value for each sample.

TABLE 2.
SR VALUE FOR EACH SAMPLE

point description	SR	point description
full shade	100%	full shade
moderated shade	70%	moderated shade
light shade	30%	light shade
no shade	0%	no shade

Petri dishes were distributed in several solar radiation exposures which measured by LUX above every sample point during sampling time. Table 3 shows solar radiation strength in sample points.

TABLE 3.
SOLAR RADIATION STRENGTH IN SAMPLE POINTS

point description	LUX	point description
Directs solar radiation exposure	32000	Directs solar radiation exposure
Moderate solar amount	19250	Moderate solar amount
moderated cloudy	4250	moderated cloudy
cloudy	265	cloudy

Petri dishes were distributed inside and around the WWTPs to find the bioaerosol sources and the average of microorganism's pollution in air. Petri dishes were distributed above the aeration tanks, above the secondary settling tanks, beside the sludge drying basin, near chlorination tanks and beside fence for the pair of WWTPs. Fig. 5 shows Mansoura WWTP description and Fig. 6 shows Meet-Mazah WWTP description. Other Petri dishes also distributed in distances of 25,150 and 250 M outside both WWTPs.

Fig. 5. Mansoura WWTP description

Fig. 6 Meet-Mazah WWTP description.

3 RESULTS AND DISCUSSION

Most of the estimated values refer to a high bioaerosol pollution inside and around the WWTPs. Most of the values are more than 2500 CFU/M^3 that is high contamination of bioaerosol according to CEC.

The pollution values presented that: the lowest ratio was collected nearby the Chlorination tanks with 398 CFU/M^3 in Mansoura and 1858 CFU/M^3 in Meet-Mazah respectively. Inversely the highest pollution values were above the aeration tanks, with "uncounted value" in Mansoura WWTP; this value refers to much polluted environment in this place and 6170 CFU/M^3 in Meet-Mazah WWTP. The values prove that, in Mansoura WWTP and Met-mazah WWTP the aeration tanks are the main bacterial source.

After subtract the pollution values of aeration tanks from the both WWTPs, the average of other values in Meet mazah WWTP is more than this average in Mansoura WWTP. This refers to higher bioaerosol pollution in Meet-Mazah, this pollution may return to the agriculture area around Meet-Mazah WWTP. Fig. 7 shows the bioaerosol pollution distribution in Mansoura and Meet-Mazah WWTPs.

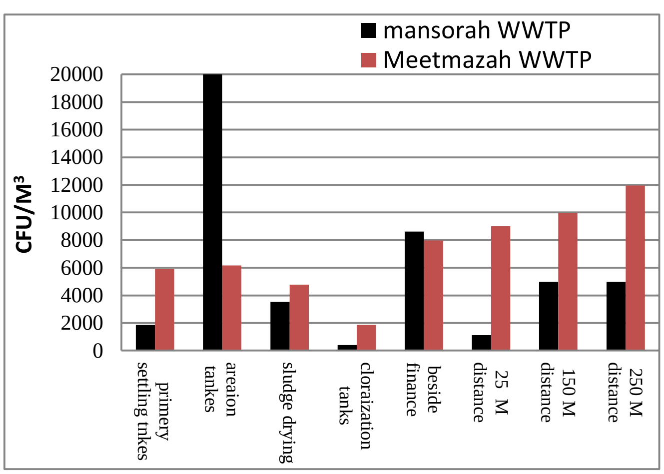

Fig. 7. The bioaerosol distribution in Mansoura and Meet-Mazah WWTPs..

3.1 PLANTING COVER EFFECT

Without plants in PCR=0, the pollution values were from 796 to 1990 CFU/M^3, with standard deviation 592 CFU/M^3, and average equal 1366 CFU/M^3, it is the lowest average. And for the area of PCR = 1.1 the average of bioaerosol pollution increased to 2670 CFU/M^3. Thereby in the moderated planting area with PCR=2.2 the bioaerosol pollution average had a significant increase to reach 9765 CFU/M^3. Also for the area of PCR = 3.25 the bioaerosol pollution average increased to 14597 CFU/M^3, that is showing the cumulative effect of planting cover on the bioaerosol.

The average of bioaerosol pollution increases by the planting coverage ratio. The plants increase the ability of microorganisms to survive, and create good condition to grow up on the surface of the plant and on the earth surface. Fig. 8 shows planting cover effect on bioaerosol pollution.

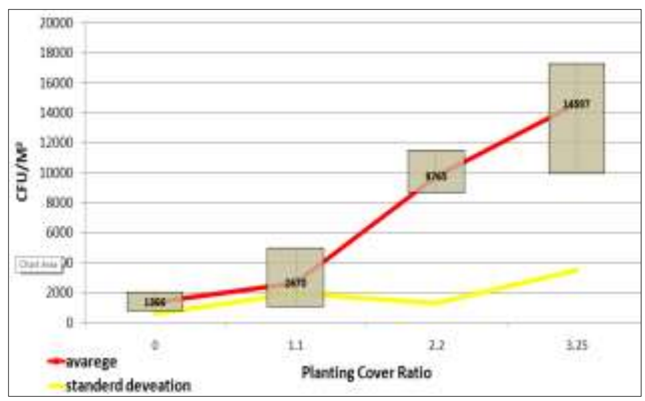

Fig. 8 Planting cover effect on bioaerosol.

3.2 SHADING EFFECT

The pollution values are showing that, in 100% shaded area the bioaerosol pollution was very high with result of 19904 CFU/M^3, and the pollution was decreased by decreasing shading ratio. Otherwise in no shading area the result was decreased to the quarter "4972 CFU/M^3". In all samples bioaerosol pollution is increased by shading ratio. And there is a direct relationship between shading ratio and bioaerosol pollution. Fig. 9 shows shading effect on bioaerosol pollution.

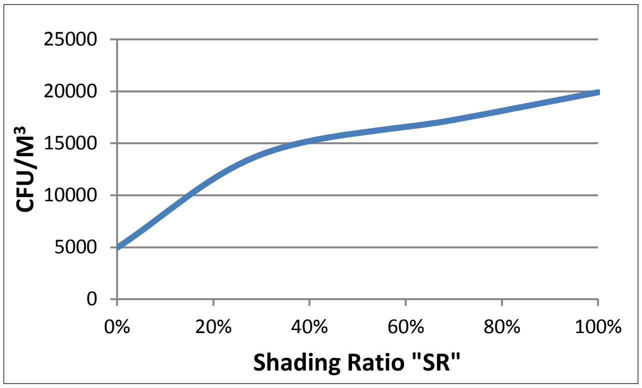

Fig. 9 Shading effect on bioaerosol pollution

3.3 *SOLAR RADIATION EFFECT*

An inversely relationship between solar radiation and bioaerosol was found, especially under high radiation, at noon with 32000 LUX the result was 796 CFU/M^3, thereby the pollution values increased under less solar radiation, where at point with very low radiation with 265 LUX, the bioaerosol pollution was very high with 13933 CFU/M^3. Fig.10 showing the solar radiation effect on bioaerosol pollution.

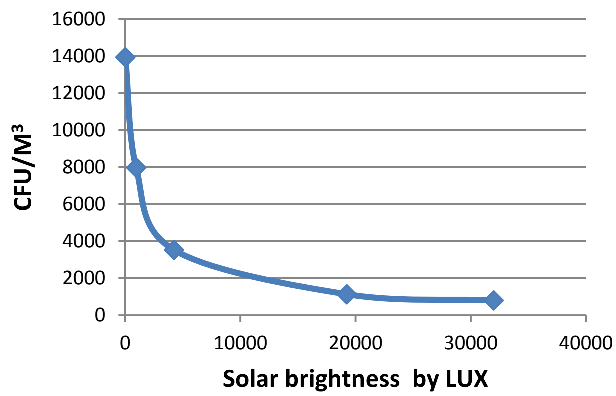

Fig. 10 Solar radiation effect on bioaerosol pollution.

4. CONCLUSION

Planting cover density, shading and solar radiation directly effect on bioaerosol pollution. There is a direct relationship between bioaerosol pollution and planting density. Increasing of plants can multiply the pollution to more than 10 times from 1366 to 14597 CEU/M^3 , not only planting density but also shads can multiply the pollution to around 4 timed from 4976 to 19704 CFU/M^3, so decreasing of this two parameters in WWTPs and around it will decrease the pollution ratio in these areas. Conversely, there is an inversely relationship between solar radiation and bioaerosol pollution. Solar radiation can decrease the pollution ratio to 5% from 13933 CFU/M^3 to 796 CFU/M^3 so solar radiation can be considered the most effective natural way to treat the bioaerosol pollution and minimize its hazard inside and around the WWTPs.

Increasing the solar radiation amount in WWTPs is needed, especially around the aeration tanks. And more solar radiation amount must be provided inside the buildings around the WWTPs.

Choosing a sunny place away from buildings or agriculture areas to implement new WWTPs, and aeration tanks should be located away from any buildings or fixtures causing shades. Minimizing the planted areas, plants density and shade in WWTPs, especially in downwind direction and quit it near the aeration tanks.

ACKNOWLEDGMENT

This work was supported by Mansoura University and Environmental Engineering and Management Technology Program.

REFERENCES

[1] M. Vitězova, T. Vitěz, H. Mlejnkova & T. Lošak (2012) Microbial contamination of the air at the wastewater treatment plant, ACTA Universitatis agriculture et silviculturae mendelianae brunensis.
[2] Z. Filipkowska, W. Janczukowicz, M. Krzemieniewski & J. Pesta (2000) Microbiological Air Pollution in the Surroundings of the Wastewater Treatment Plant with Activated-Sludge Tanks Aerated by Horizontal Rotors.
[3] Thermal, Chemical, and Photocatalytic Inactivation of Lactobacillus plantarum Bacteriophages,1,Journal of Food Protection, Vol. 72, No. 5.
[4] J. Douwes , P. Thorne , N. Pearce & D. Heederik (2002) Bioaerosol Health Effects and Exposure Assessment, Published by Oxford University Press.
[5] F. C. Tsai & J. M. Macher (2005) Concentrations of airborne culturable.lkiiuy\' bacteria in 100 large US office buildings from the BASE study, Indoor Air.
[6] R. Marzenna Dudzinska (2009) Management of indoor air quality, Taylor & Francec, London, 2011
[7] Sa´nchez-Monederoa M.A., Aguilarb M.I., Fenolla R. & Roiga A. (2008) Effect of the aeration system on the levels of airborne microorganisms generated at wastewater treatment plants, Technological.
[8] C. S. Cox & C. M. Wathes, (1995), Bioaerosols Handbook, CRC Press, ISBN 1-87371-615-9, pages 285-316.
[9] P. Feng, D. Stephen Weagant (ret.), Michael A. Grant (dec.), William Burkhardt, 2002, Bacteriological Analytical Manual, Enumeration of Escherichia coli and the Coliform Bacteria, https://www.fda.gov/default.htm