IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

The presence of insect at composting

To cite this article: J Mudruka *et al* 2017 *IOP Conf. Ser.: Earth Environ. Sci.* **92** 012045

The presence of insect at composting

J Mudruňka[1], B Lyčková[2], R Kučerová[2], V Glogarová[2], J Závada[2], B Gibesová[1] and D Takač [2]

[1]VŠB-Technical University of Ostrava - Institute of combined study in Most, Budovatelů 2830/3, Most 434 01, Czech Republic
[2]VŠB-Technical University of Ostrava - Faculty of Mining and Geology, 17. listopadu 15/2172, 708 33 Ostrava-Poruba, Czech Republic

Email: jaroslav.mudrunka@vsb.cz

Abstract. During composting biodegradable waste, microbic organisms reproduce massively, most of which belong to serious biopathogens which are able to penetrate various environmental layers. Their vector species include dipterous insect (*Diptera*) which reaches considerable amounts in composting plant premises as well as home composting units, mainly during summer months. Therefore measures must be taken to eliminate or reduce this unwanted phenomenon (sanitisation, disinfection). For evaluating obtained results, relative abundance calculation was chosen.

1. Introduction
When handling waste, there is always real probability of environmental hazards because during decomposition of biodegradable materials, a lot of microorganisms of autochthonous type [1]. Pathogenic bacteria, fungi and their spores can contaminate not only at processing plants, but it also can, by wind or vectors, penetrate their surroundings and pose a risk for people, animals and plants. Mainly some species of dipterous insect (*Diptera*) the imagos of which lay their eggs into waste and also into maturing substrates and larvae of which develop and cocoon, can transmit a plenty of infectious diseases on their bodies or via their digestive tract [2]. Within a research which was carried out during 2016, selected species of this insect were detected and taxonomically determined at home composting unit and at composting plant.

2. Environmental hazards of composting
Composting is the optimum way of biowaste processing because it influences environmental layers only marginally and the final product can be used as quality natural organic fertilizer. However, during composting, the surrounding is polluted with microorganisms, volatile organic compounds of microbic origin and smell [3]. The unignorable risk factor is dipterous insect (*Diptera*) penetrating into composting plants premises and into home composting unit because biodegradable waste, as well as maturing substrate, is suitable environment for its eggs, larvae and nymphs. With increased presence of insect, humans or animals can be attached upon directly, while serious level of infestation with insect larvae (myiasis, pseudomyiasis) cannot be avoided. However, such risks are negligible, and they can be totally eliminated due to maintaining principles of proper hygiene [4].

On the other hand, there exists highly serious risk of subsequent transmission of microbial pathogens on a body and or in insect mouthparts. Biopathogens transmitted by them can be a potential source of infections and cause diseases not only by its infectiousness, but also by toxins produced. An immensely dangerous biopathogen is bacteria *Escherichia coli* phyla of which are commonly present in livestock guts and together with excrements can be taken into compostable biowaste. During infection, significant health complications may occur. Another significant thing is a danger of contaminating plant surfaces with this bacteria [5]. There can also appear pathogenic species *B. anthracis* from *Bacillus* phylum which attacks animals as well as humans while its impact is fatal. In composts, there can also be bacteria of *Streptococcus* phylum out of which several species are significantly pathogenic [6]. In such cases, the risk of transmission in insect mouthparts is particularly serious. Also the risk of contamination with bacteria *Clostridium botulinum* is relatively high as it produces botulinum neurotoxins with fatally toxic effects [7]. The presence of larvae of *Calliphoridae* family, in GIT of which there are colonies of the above mentioned bacteria in high concentrations. The premises and surroundings of composting plants are also contaminated with spores of various fungi (e.g. *Aspergillus*) which implies that their secondary transmission on insect bodies is highly probable. However, the risk of fungi and microscopic fungi and their transport via insects exists also during home composting or in connection of insufficiently hygienic collection and assembling of biowaste (including so-called kitchen) [8].

3. Characteristics of dipterous insects (*Diptera*)

Out of approximately over a million described insect species, about eighty six thousand belong to *Diptera* order (*Diptera)* all species of which have large compound eyes. Their mouthparts can differ – a rostrum might be missing or it might be reduced. The mesothorax is mightly vaulted and a single pair of fore wings grows out of it, while the hind pair is reduced to small halters. Each part is each body segment has a pair of differently shaped legs [9]. The twelve-part abdomen can have the last parts transformed due to easier reproduction. Dipterous insect are sexually dimorphic. Females lay glossy and mostly white eggs (length of about 1 mm and width of about 0.4 mm) at places with sufficient humidity and food source. After larvae hatch, three stages of their development take place and at the end a larva pupates. The perfect metamorphosis of *Diptera* in a pupa is finished with an adult emerging from it [10] [11]. Occurrence of this insect is tied to suitable life conditions which can mainly be found near human habitations because larvae and adults feed on plant or animal tissues, kitchen waste, feces and so on [12]. From the anthropogenic point of view, it is possible to divide this order into insignificant, useful and harmful species; the last to be named can damage plants, parasitize on animals and carry pathogens [13] [14]. Taxonomically, the order divides into several families out of which the most important ones, due to the issue presented her, are *Muscidae*, *Calliphoridae*, *Cordyluridae*, *Scatophagidae*, *Sarcophagidae*, as well as *Drosophilidae* [15].

4. The method of detection and insect determination

The research itself was implemented from April till October 2016 at the premises of a composting plant in Ustecky district and simultaneously in the garden of a family house in a garden suburb approximately 20 km far from the composting plant mentioned above. The composting plants processes 80,000 tons of biodegradable waste per year, the waste is laid in dumps in the building of operating halls. Food waste is also composted here, which is, after sanitising in a fermentation box together with cut grass and wood chippings mixed into common biowaste. Suitable trap devices were located in the area of the composting plant, namely "flychatchers" (glued paper bands with chemical attractant, and plastic bowls of white and yellow colour which were filled with water with formaldehyde (4%) and detergent. The home compost is a usual one: it is a fill of 2 x 1 m, laid directly on the ground with board fender lining where usual biowaste from household and garden is put. Trap devices were also installed near the compost site ("flycatchers" and bowls). The trapped insects were killed in a killing jar and they were taxonomically determined.

One of the most substantial factors which has crucial influence on the process of entomologic sampling is weather at the given site and at the given time. *Diptera* mostly belong to sun-loving insect species therefore their occurrence at the sites is at its fullest during sunshine. At the time of low temperatures, insect is rather inactive but this also applies at the time of extremely high temperatures.

Also during rainfalls, most insects are hidden. Also wind is very important for detection of insect individuals itself as in case it is stronger or in case of turbulence, insect is carried by airstream. All the weather data were obtained via our own measurements, personal observation (rainfall, cloud amount) or from Czech Hydro-meteorological Institute database in Prague (wind force, wind direction).

Due to the fact that large amounts of various insects were found in bowls and flycatchers, we selectively chose only such species which taxonomically belong to Diptera order, and also number of which exceeded numbers of other insect species caught and at the same time, indeterminable specimens were excluded (destroyed body, etc.).

5. Evaluation of the obtained results

For evaluating obtained results, relative abundance calculation was chosen. This term of ecological statistics expresses amount of insect individuals of the given species related to certain predetermined type of quantitative sampling method. In this particular case it was the total amount of caught specimens to the total amount of obtained samples. Calculations were implemented via below mentioned Equation (1) while the total amount of individuals of the observed species was determined as the total sum of all insect individuals of the given species caught in calendar month and the total amount of obtained samples was the total sum of individual samples in one month (one individual sample per one day):

$$RA = \frac{S_n}{S_{vz}} \quad (1)$$

where: RA = relative abundance; S_n = number of individuals of the observed species; S_{vz} = total amount of obtained samples.

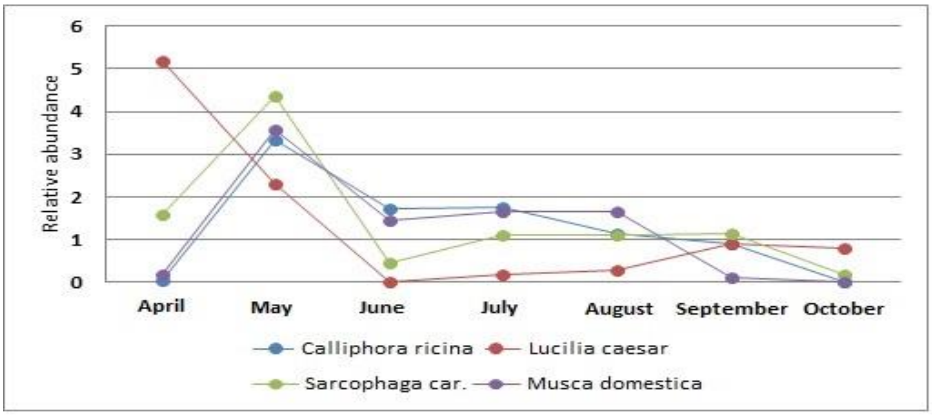

Figure 1. Values of relative abundance – composting plant.

As evident from relative abundance calculations, (see figure 1 and figure 2), numbers of all species of *Diptera* were during the observed period of time considerably higher in the premises of the composting plant. Mainly in case of *Sarcophaga carnaria* and *Musca domestica* (housefly), the difference is particularly obvious. Increased amounts of insect in the composting plant are certainly caused by much bigger volume of composted waste material than it is in case of home composting unit. Also, muck is not included into a fill in a private garden which explains increased amount of insect in the composting plant because such waste is normally processed there. Also very small amount of food waste which gets into a home composting unit is the reason why *Sarcophaga carnaria* only rarely occurs here. In operation halls where constant air circulation (draught) is apparent, amount of caught insects is substantially lower that it is at outside dumps of still unprocessed biowaste. If we compare data on climatic conditions in the given area with records on amount of detected insects, we can confirm the known information about life cycle of the given insect species.

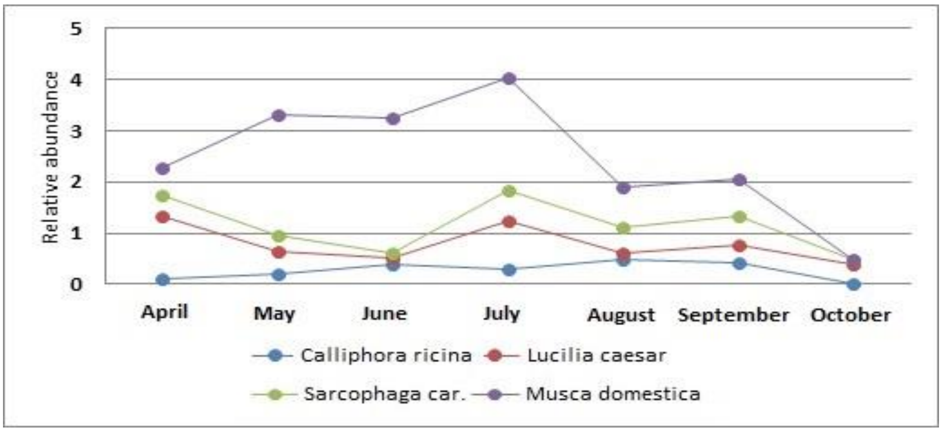

Figure 2. Values of relative abundance – home composting unit.

For instance, *Calliphora vicina* R. D. is mostly active at temperatures of about 27 °C while cryophilic *Lucilia caesar* L. can be observed already at temperatures under 10 °C. Thus it may be claimed that data obtained via the performed entomologic sampling confirm eventual assumption about abundant occurrence of *Diptera* during composting. It is evident that amount of *Diptera* can, mainly during summer months, reach considerable values, namely at premises of industrial composting plants during processing so-called food waste or muck.

6. Sanitation options

Based on findings of increased and undesirable occurrence of *Diptera* at places where biowaste is being processed via composting, it is necessary to take such measurements which would eliminate or substantially reduce this feature. Mainly it is essential to avoid penetrating of adult individuals to the collected biowaste. This will avert the risk of transmission of microbial pathogens on insect bodies into surrounding parts of the environment, simultaneously it limits the possibility of laying insect eggs.

All containers in which biowaste is transported into a composting plant have to air-proof lockable and sealed and they have to be sanitized properly in exactly given intervals. This requires suitable logistic plans and operating instructions and attend to their following, together with operational alternations (e.g. according to the development of meteorological conditions, etc.). It is obvious that transmission of biopathogens via insect can normally happen during further operational processes too (biowaste grinding, basing dumps, etc.). Sanitization of all technological devices (machinery, tools, and vehicles) therefore appears to be necessary. However, sanitization itself is focused only on elimination of microbial pathogens concentration in biowaste and substrates and does not concern presence of insect in the premises of a composting plant or in the surroundings of a home composting unit. Therefore it is required to ensure a suitable disinsection method too. Disinsection methods are generally divided into precautionary (prophylactic), repressive (exterminating) and integrated. The above mentioned technical precautions and sanitization can be considered a part of group 1 because they help to create such environment state where insect reproduction is limited. Repressive methods can be mechanical (flycatchers, traps, collectors and so on). This procedure is long and ineffective. Even the application of the most modern methods (collectors with pheromones and other attractants) did not make this method more effective, therefore they are used only for obtaining entomological samples. An interesting and usable in smaller composting plants repressive method can be treatment of biowaste or substrates with hot steam which kills insect eggs, larvae and imagoes. In the conditions of home composting unit, shedding the base with boiling water can be recommended as realistic because the boiling temperature is lethal for all development stages of insect.

Due to undesirable secondary effects on environmental layers and on human health and also to negative impacts on life cycle of necessary microorganisms in substrate, direct application of chemical insecticidal substances into compost cannot be recommended. Also coating of compost site walls or fencing the composting plant or spraying collecting vessels with repellents are not suitable due to their toxicity. On the contrary, disinsection performed using biological methods during which natural enemies of insect species are used is optimal. In case of *Diptera* these are parasitic wasps of *Spalangia* L. Also application of simple mechanical means, e.g. covering the base and substrates with permeable technical cloths or fine netting is able to prevent penetrating insect. This protection method appears to be suitable in conditions of home composting unit. Also adding fresh-cut grass to biowaste is useful because fresh-cut grass decreases prosperous life conditions for pathogenic microorganisms and neither *Diptera* which seeks decaying organic substances is attracted to a base treated this way. This simple method can effectively reduce the presented environmental risks.

7. Conclusion

Emissions of bio-aerosols and transmission of infectious diseases agents via *Diptera* can be considered significant environmental risk threatening not only workers at the processing plants in question, but also residents, animals and plants in the surroundings. This fact gives rise the need to prevent insect penetrating into compost and necessity to implement disinsection and protection interventions. For the present, neither precepts of law, nor technical and methodological regulations do not make provisions for such risk and only specify limits of concentrations of chosen microbial pathogens in composting substrate. They do not concern with expositions of bio –pathogens into atmosphere of composting plants, neither have they determined mandatory regulations for eliminating their spread via insect.

Even though entire elimination of the environmental risk in question is due to the character of the risk factor – i.e. *Diptera* – fundamentally impossible, performing protection and elimination precautions during composting biowaste is absolutely necessary because transmission of microbial pathogens via insect can be considered undoubtedly undesirable feature.

Acknowledgements

This paper was compiled within the Project of Specific University Research (SGS) no. SP2017/31 Processing of animal excrements in vermicompost.

References

[1] Awasthi M K, Pandey A K, Khan J, Bundela P S, Wong J W C and Selvam A 2014 Evaluation of thermophilic fungal consortium for organic municipal solid waste composting *Bioresour. Technol.* **168** pp 214–221

[2] Albrecht A, Witzenberger R, Bernzen U and Jäckel U 2007 Detection of airborne microbes in a composting facility by cultivation based and cultivation-independent methods *Ann. Agric. Environ. Med.* **14** pp 81-85

[3] Fischer G, Albrecht A, Jackel U and Kampfer P 2008 Analysis of airborne microorganisms, MVOC and odour in the surrounding of composting facilities and implications for future investigations *Int. J. Hyg. Environ. Health* **211** pp 132–142

[4] Zimová M and Matějů L 2014 *Kompostování odpadů a potencionální riziko mikrobiální kontaminace* (Praha: Státní zdravotní ústav v Praze) p 5

[5] Kůdela V 2012 Úloha rostlin v epidemiích způsobovaných toxigenními kmeny střevní bakterie Escherichia coli *Živa* **3** pp 110-112

[6] Schindler J 2010 *Mikrobiologie pro studenty zdravotnických škol* (Praha: Grada Publishing, a.s.) p 224

[7] Ltibke U 2016 *Microbial Inoculants for Controlled Composting of Organics Materials* (Peuerbach: Controlled Microbial Composting Group, Austria) p 4

[8] Herr C E, Zun Nieden A, Stilianakis N I and Eikman T F 2004 Health Effects Assiciated with Exposure to residential Organic dust *Am. J. Ind. Med.* **46** pp 381-385

[9] Hudec K, Kolibáč J, Laštůvka Z and Peňás M 2007 *Příroda České republiky-průvodce faunou* (Praha: Academia) p 440

[10] Mai M and Amendt J 2012 Effect of different post-feeding intervals on the total time of development of the blafly Lucilia sericata (Diptera: Calliphorodae) *Forensic Science International* pp 65-9

[11] Genard Zuha R, Razak M, Ahmad T A and Omar B 2012 Interaction effects of temperature and food on the development of forensically important fly, Megaselia scalaris (Loew) (Diptera: Phoridae) *Parasitology Research* p 2187.
[12] Byrd J H and Castner J L 2010 *Forensis Entomology: The Utility of Arthropods in Legal Investigations* (BOCA Raton: CRC Press) p 681.
[13] Laštůvka Z et al. 2001 *Zoologie pro zemědělce a lesníky* (Brno: Konvoj) p 267
[14] Showler A T and Osbrink L A 2015 Stable Fly, Somoxys calcitrans (L.). Dispersal and Governing factors *International Journal of Insect Science* **7** pp 19-25
[15] Javorek V 1967 *Kapesní atlas dvoukřídlého hmyzu* (Praha: Státní pedagogické nakladatelství) p 269.