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Aim and Scope

Quality of Life publishes original research papers and reviews and aims to provide a forum for the rapid dissemination of significant novel research in the various disciplines encompassing the Science and technology of food, Public health engineering, Sanitary inspection and control, Environmental and public health. Topics covered by the journal include:

- Dietetics; Nutrition principles applied to foods
- Food Technology; Production and preservation of foodstuffs; Food preservation technique
- Industrial microbiology; Science and technique of applied microbiology; Applied mycology
- Public Health, environment and hygiene
- Hygiene of air, water, soil; Pollution and its control
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DEAR READERS AND AUTHORS,

As Editor-in-Chief of the journal *Quality of Life*, I look forward to the challenge of creating a journal that will enhance the quality of research in the various disciplines encompassing the Science and technology of food, Public health engineering, Sanitary inspection and control, Environmental and public health in our country, region as well as at the international level. The goal that we have set is high but not unachievable.

The journal *Quality of Life* was registered in the Register of Public Media in 2010 by the Decision of the RS Ministry of Education and Culture. Over the past years, this journal has published a large number of original scientific research papers, communications and review papers. *Quality of Life* is published twice a year by Pan-European University “Apeiron” Banja Luka.

All the papers published so far have undergone a thorough review by the editorial board and the reviewers, made up of experts from both RS/B&H, the surrounding and other countries, from proven and recognized university and research institutions. As a result of a professional approach to selecting and reviewing papers, and raising the quality of the journal, *Quality of Life* was classified in the first category of journals in 2019 by the Ministry of Education and Culture. We are proud to say that *Quality of Life* has been well received by the scientific and the general public in a relatively short period of time, which gives the editorial board a strong motivation for further work.

The editorial team would like to thank our many reviewers who helped to maintain the journal standard; our many authors who submitted their best work to the journal; and, most important, our readers for your continuing support.

I shall assure all our readers that our consistent efforts will be aimed toward increasing the visibility, impact, editorial cycle time, citations and the overall quality of our journals. We very much look forward to strengthening the reputation of our publications, and we want to attract more higher-quality submissions. I hope our readers and patrons share a similar vision, and we look forward to a productive, challenging and successful 2020 ahead. In the spirit of continuous improvement, any constructive input on streamlining our processes is very welcome.

Please help us grow by citing articles that you read in *Quality of Life*. We look forward to receiving your contributions in the near future.

Editors

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Original scientific paper

RESEARCH ON THE INFLUENCE OF PRENATAL EXERCISE ON THE TYPE OF DELIVERY

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Abstract: INTRODUCTION / OBJECTIVE Pregnant women were not recommended to exercise because there was a risk of preterm delivery. Prenatal exercise however may reduce the risk of preterm delivery by other mechanisms such as reduced oxidative stress or improved placental vascularization. Given that the number of cesarean deliveries is growing and that a moderate-intensity physical activity can have a beneficial effect on mother and fetus, it is necessary to determine the frequency of delivery with pregnant women who performed prenatal exercises and those who did not exercise.

MATERIALS AND METHODS: One hundred and twenty pregnant women participated in the study (n = 120). Pregnant women who attended only the theoretical part were included in the control group (n = 59). By joining the experimental group, pregnant women (n = 61) participated in both the theoretical part and prenatal exercises. We followed each participant for 8 weeks, which is the duration of one cycle of psychophysical preparation.

RESULT: In the group where pregnant women practiced prenatal exercises, vaginal deliveries predominate, almost twice as many as cesarean births. On the other hand, in the group where pregnant women did not exercise there is a slight decrease in the frequency of vaginal deliveries, with a tendency to equalize the results because there is an evident increase in the cesarean sections in that group. The application of the chi-square test did not determine the presence of a statistically significant difference in terms of delivery between the group of pregnant women who practiced prenatal exercises and those who did not.

CONCLUSION: Prenatal exercise of moderate intensity has a positive impact on the type of delivery. Although no statistically significant difference was observed between pregnant women who exercised and those who did not, there is a tendency for an increase in vaginal delivery in pregnant women who performed prenatal exercise.

Keywords: prenatal exercises, pregnancy, type of delivery

INTRODUCTION

In the past, pregnant women were not recommended to exercise because there was a risk of preterm delivery. Theoretically, physical activity increases the release of catecholamines, especially norepinephrine, which can stimulate myometrial activity. In reverse, prenatal exercise may reduce the risk of preterm delivery by other mechanisms such as reduced oxidative stress or improved placental vascularization (1). Numerous studies emphasize the impact of regular physical activity on health before pregnancy, during pregnancy and after the delivery (2).

The frequency of cesarean sections during deliveries is on the rise. The data show that this number exceeds much more than the recommended 10 to 15% by the World Health Organization (WHO) (3). The number of cesarean sections is increasing in the richest regions and is directly related to higher education (3). One of the proposals to try changing this condition is a regular prenatal exercise.

Prenatal exercises are associated with a lower rate of cesarean delivery in nulliparous women (3). The results of a randomized controlled study involving 2,059 pregnant women showed that the women in the exercise group had a significantly higher incidence of vaginal delivery (73.6%) compared to those

who did not exercise (67.5%). Also, the results showed a significantly lower incidence of caesarean section (17.9%) in pregnant women who exercised compared to 22% in those who did not exercise (1).

Physical activity in pregnancy has many benefits, such as reducing edema in pregnant women, reducing the risk of developing gestational diabetes, smaller weight gain, relieving lower back pain, reducing the incidence of urinary incontinence etc. (3). One of the first sources to publish recommendations or guidelines for performing physical activity during pregnancy was the American College of Obstetricians and Gynecologists (ACOG). According to ACOG guidelines, in the absence of obstetric complications, moderate exercise is recommended for pregnant women for thirty minutes a day or more, most days of the week (4). Exercise during pregnancy can reduce the risk of gaining weight and this will have a positive effect on the birth weight of a newborn (5). Birth weight over 4000 g causes a higher frequency of postpartum hemorrhage, cesarean delivery, shoulder dystocia, birth trauma as well as an increased risk of developing obesity and diabetes mellitus later in life (6). Fixed positions, such as certain yoga positions and supine positions with outstretched legs, should be avoided as much as possible due to the possibility of reduced venous flow and hypotension in 10-20% of all pregnant women (4).

The American College of Obstetricians and Gynecologists (ACOG) presented absolute and relative contraindications for exercise in pregnancy. Absolute contraindications for exercise in pregnancy are: cardiovascular disease, restrictive lung disease, incompetent cervix or cerclage, preterm birth, persistent bleeding in the second and third trimesters, placenta previa, premature contractions during pregnancy, rupture of fetal membranes, preeclampsia or pregnancy-induced hypertension, severe anemia.

Relative contraindications for exercise in pregnancy are: anemia, maternal arrhythmia, chronic bronchitis, poorly controlled type 1 diabetes, extreme obesity, extreme underweight ($BMI < 12$), extremely sedentary lifestyle, IUGR in current pregnancy, poorly controlled hypertension, orthopedic limitation, poorly controlled hyperthyroidism, heavy smokers.

Physiological responses to exercise, such as changes in heart rate, cardiac function, ventilation and energy expenditure during pregnancy, may become more pronounced as the pregnancy progresses. In addition, during pregnancy, hormonal changes increase the joint laxity, which can increase the risk of injuries. In order to reduce the risk of injury for both mother and child, it is necessary to adjust prenatal exercises in terms of duration, intensity as well as the type of exercise (7).

Given that the number of cesarean births is growing, and on the other hand medium-intensity physical activity can have a beneficial effect on mother and fetus, it is necessary to determine the frequency of delivery (cesarean section or vaginal delivery) in pregnant women who performed prenatal exercises and pregnant women who did not exercise.

MATERIALS AND METHODS

One hundred and twenty pregnant women ($n = 120$) participated in the study.

The participants in the study were pregnant women from the northwestern part of Bosnia and Herzegovina who attended birth preparation program for delivery in the period from January to June 2020. They joined the program at the earliest in the 20th week of gestation, and at the latest in the 32nd week of gestation. We followed each participant for 8 weeks, which lasted one cycle of psychophysical preparation for delivery.

The study was approved by the Ethics Committee of the Medical Faculty in Banja Luka. Participants received verbal information on how the study was conducted, and read the Information for the Participant for the mentioned research. The participants who voluntarily agreed to participate in the research signed an informed consent form. The study was conducted in accordance with the ethical rules of the Declaration of Helsinki.

Criteria for inclusion in the study

Criteria for inclusion in the study were: age of pregnant women from 20 to 40 years, normal pregnancy confirmed by a gynecologist, duration of pregnancy from 20 to 32 weeks of pregnancy, BMI before pregnancy $<25 \text{ kg} / \text{m}^2$, single gestation.

Criteria for non-inclusion in the study

Criteria for non-inclusion in the study were: multiple pregnancy, diagnosis of placenta previa, acute or chronic diseases, cerclage, extreme obesity, extreme malnutrition, diabetes mellitus, hypertension, smoking in pregnancy.

Criteria for exclusion from the study

Criteria for exclusion from the study were: bleeding in the second or third trimester, premature birth in the current pregnancy, rupture of the amniotic sac, preeclampsia or pregnancy-induced hypertension, IUGR in the current pregnancy, anemia and exclusion from the study at the pregnant woman's own request.

After the gynecological examination, the gynecologist included the pregnant women in the prenatal program, which included theoretical classes about delivery and prenatal exercises. The respondents were divided into two groups: control and experimental group. Pregnant women who attended only the theoretical part were included in the control group. Pregnant women from the control group participated in the theoretical part for 60 minutes three times a week where they received pieces of advice from gynecologists on pregnancy, delivery, the advantages of vaginal delivery over cesarean delivery, positions taken during the delivery, diet, breastfeeding etc.

By joining the experimental group, pregnant women participated in both the theoretical part and prenatal exercises. The experimental group exercised three times a week for 45 minutes at agreed times. Prenatal exercises were led by the therapist for physical activities in pregnancy, according to the exercise program made in compliance with the recommendations of the American College of Obstetricians and Gynecologists (4) and the guidelines of HUFZZ (*Croatian Association of Physiotherapists for Women's Health*) (8,9).

During the study, pregnant women did not exercise further in other places. The recommendation was to eat normally, not to eat or drink anything for an hour before exercise, except water. During the exercise, pregnant women were well hydrated, wore light clothing, and avoided high heat and humidity to protect themselves from heat stroke. The room in which they practiced was air-conditioned, and the room temperature did not exceed 24°C .

The exercise program comprised: static and dynamic breathing exercises, muscle stretching exercises and muscle strength exercises, exercises to strengthen the abdominal wall muscles, exercises to strengthen the thigh muscles - quadriceps femoris (*lat. musculus quadriceps femoris*), to strengthen gluteal muscles, exercises to increase pelvic mobility, exercise to improve circulation, as well as pelvic floor muscle training with relaxation techniques.

During the prenatal exercises, we monitored the exercise intensity for pregnant women based on the subjective feeling of exertion. The applied physical activity was of medium intensity, using the *Borg Rate of Perceived Exertion (RPE) Scale* (4) as a reference when explaining to pregnant women that they should stop doing it when they subjectively feel it is "moderately difficult". Another way to measure the exertion is to use "*The talk test*". It is believed that as long as a pregnant woman can have a conversation during the exercise, she is probably not overexerted (4).

Pregnant women were warned to stop the activity if they feel dizzy, short of breath, pain, muscle weakness, difficulty with breathing on exertion, if they bleed or notice the signs of the onset of labor, or if they notice reduced fetal movements. Also, they were additionally warned to be careful when stretching to avoid injuries.

Pregnant women were required to attend 80% of prenatal exercise classes in order to remain included in the study. In addition, they could leave the research at their own request. The respondents in both groups filled out a questionnaire during the study from which we obtained the following data: age, height and body weight before pregnancy. From the medical records of the pregnant women who brought them for inspection, we obtained the data on the week of pregnancy. After the delivery, we sent a postnatal questionnaire electronically to the participants from both groups, from which we obtained the data on the type of delivery (vaginal or caesarean section).

The data were processed by methods of descriptive and parametric statistics using the program SPSS 20.

RESULTS

A total of 135 pregnant women were included in the prenatal exercise program of which 120 pregnant women successfully completed the program (88.9%), while 15 pregnant women (11.1%) left the program (Chart 1).

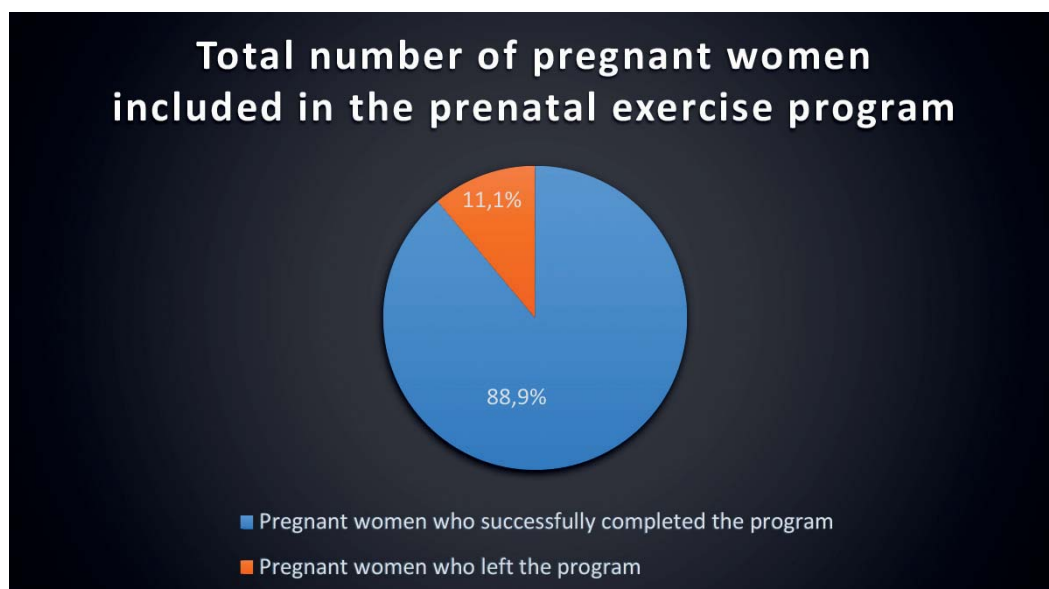


Chart 1. Total number of pregnant women included in the prenatal exercise program

At the beginning of the study, 135 pregnant women participated however 15 pregnant women left the study for the following reasons: miscarriage (1 pregnant woman from the control group), premature birth (1 from the control group, 1 from the experimental group), pregnancy-induced hypertension (2 pregnant women from the control group), leaving the study at their own request (1 pregnant woman from the control group, 2 pregnant women from the experimental group), failure to meet the minimum number of visits to the program (1 pregnant woman from the control group, 2 pregnant women from the experimental group), not being in contact after the study and incomplete data (4 pregnant women). As a result, 120 pregnant women participated in a study examining the impact of prenatal exercise on the type of delivery. There were 61 pregnant women in the experimental group ($n = 61$) while there were 59 pregnant women in the control group ($n = 59$).

In the experimental group, pregnant women began training with breathing exercises, a warm-up consisting of moderate walking for about 5 minutes, followed by strength and stretching exercises for about 30 minutes. The training ended with relaxation techniques for about 10 minutes. The exercises were performed in a standing, sitting, kneeling and side position, with or without props (balls, ribbons, weights, etc.). The exercises performed in a supine position with bent knees during this study did not last more than 5 min, thus avoiding a reduction in venous flow. In the supine position, pregnant women performed the stretching exercises for the gluteal, paravertebral and lumbosacral muscles, as well as the exercises to strengthen the abdominal wall muscles, thigh muscles and pelvic floor muscles. The exercises were performed in two to three sets, with ten to twelve repetitions. During the 8 weeks of the monitoring while the study lasted, in the first four weeks pregnant women performed prenatal exercises in two series, and the next four weeks in three series.

In the experimental group from a total of 61 pregnant women who exercised, 42 pregnant women (68.9%) gave birth vaginally while 19 pregnant women (31.1%) gave birth by caesarean section (Chart 2).

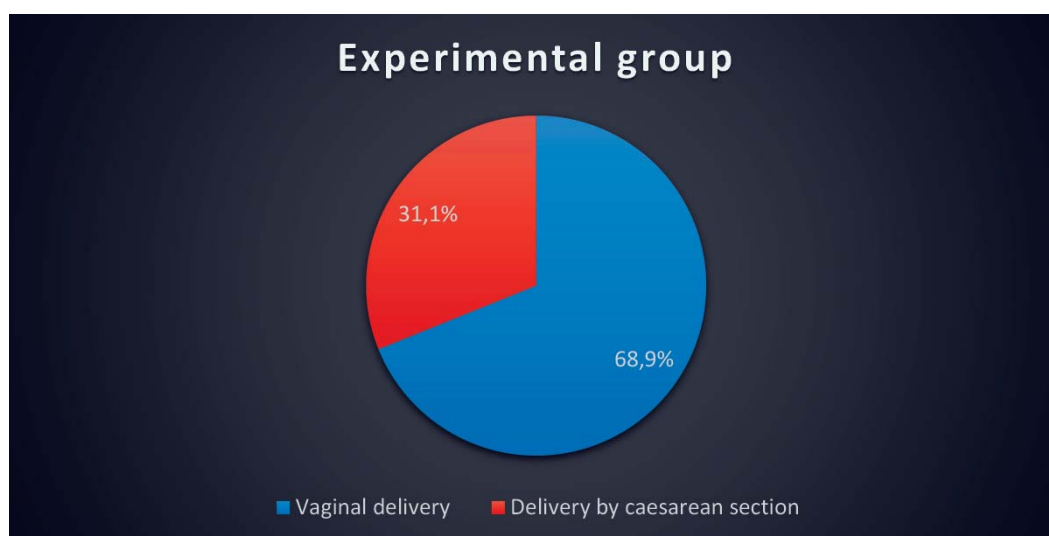


Chart 2. The delivery method in the experimental group

In the control group from a total of 59 non-exercising pregnant women, 31 pregnant women (52.5%) gave birth vaginally while 28 pregnant women (47.5%) gave birth by caesarean section (Chart 3).

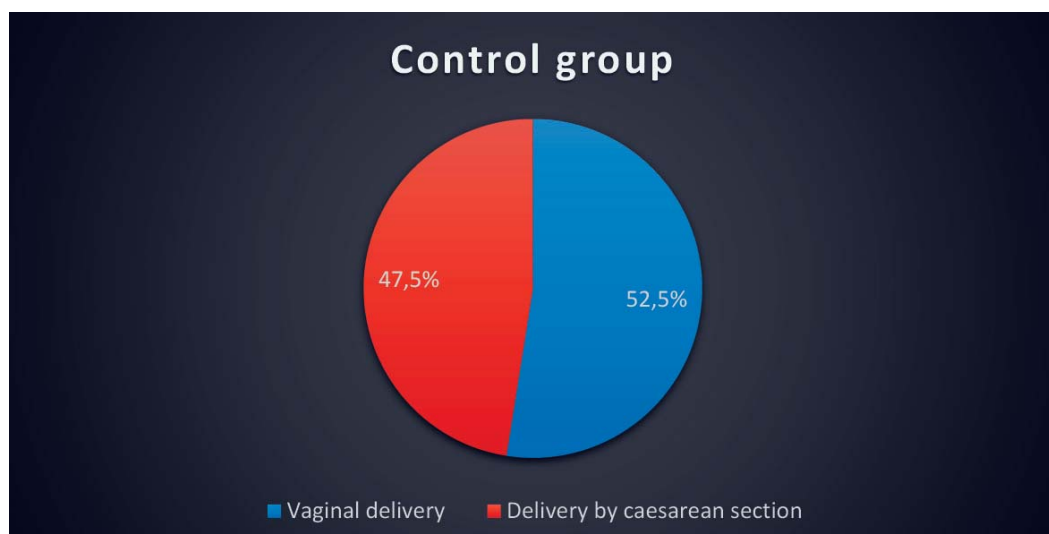


Chart 3. The delivery method in the control group

Descriptive analysis of the results shows that in the group where pregnant women practised prenatal exercises, vaginal births predominate, almost twice as many as cesarean births.

On the other hand, in the group where pregnant women did not exercise, a slight decrease in the frequency of vaginal delivery is observed, with a tendency to equalize the results because there is an evident increase in cesarean sections in that group (Table 1).

Table 1. The delivery methods in pregnant women who exercised prenatal exercises and pregnant women who did not exercise.

DELIVERY METHOD	EXPERIMENTAL GROUP EG (n=61)	CONTROL GROUP CG (n=59)
VAGINAL	42 (68.9%)	31 (52.5%)
CAESAREAN SECTION	19 (31.1%)	28 (47.5%)
IN TOTAL (n=120)	61	59

The application of the chi-square test did not determine the presence of a statistically significant difference in terms of the delivery between the group of pregnant women who practised prenatal exercises and those who did not ($\chi^2 = 3.349$, $df = 1$, $p = 0.067$). When using the chi-square test, the statistical significance $p < 0.05$ was marked as a significant difference, while $p > 0.05$ was considered insignificant.

DISCUSSION

In the study, 135 pregnant women were included in the prenatal exercise program, of which 120 pregnant women successfully completed the program (88.9%). In a study by da Silveira and co-authors out of a total of 97 pregnant women, 66 pregnant women (68%) successfully completed the program (3).

In the experimental group, 68.9% of pregnant women had a vaginal delivery, while 31.1% had a caesarean section. The results of examining the impact of the exercise during pregnancy on the type of delivery show that pregnant women who exercised with low and medium intensity had a higher rate of vaginal delivery. In a study by da Silveira et al. in the experimental group, the percentage of vaginal completion was 67.6% and cesarean section 32.4%. (3). Also, a study by Bovbjerg et al. states that exercise strengthens the abdominal muscles, which facilitates the second phase of delivery and avoids possible shoulder dystocia or excessive prolongation of delivery, which would indicate the need for a caesarean section (10). The results of a meta-analysis that included twenty-eight randomized controlled studies showed that higher volume and duration of exercise was associated with lower weight gain in pregnancy (5). The results of a controlled randomized study showed that pregnant women who did not exercise were 1.5 times more likely to gain excess weight during pregnancy than those who exercised, making it difficult to give birth naturally (11). Therefore, it is considered that women who exercise regularly during pregnancy are more likely to gain adequate weight accordingly, and in turn have an adequate newborn birth weight, which would reduce the frequency of cesarean deliveries (5).

However, it has to be mentioned that there are several studies linking moderate-intensity exercise in early pregnancy with an increased probability of cesarean delivery (12).

In the study, 52.5% of pregnant women who did not exercise had a vaginal delivery, while 47.5% of pregnant women gave birth by caesarean section. In the control group of the study by da Silveira et al., the percentage of vaginal delivery was 37.9%, while 62.1% of pregnant women gave birth by caesarean section (3).

Bungum et al. studied primiparous women who exercised during pregnancy and did not find a statistically significant difference in the type of delivery between the group that exercised and the one that did

not, which corresponds to the results of our study in which $p = 0.067$ (13). However, they observed that those pregnant women who remained inactive throughout pregnancy were about twice as likely to give birth by caesarean section (13).

In our research there are several limitations that also affected the results which concern the fact that the participants were not randomly selected, then giving up exercising in some part of the program, or giving incomplete data on doing exercises elsewhere.

In the study, all pregnant women attended the training classes that highlight the advantages of vaginal delivery over cesarean section, which increases their motivation to give birth naturally and certainly reduces the differences in the way of delivery between the group of pregnant women who exercised and those who did not.

The described birth preparation program was developed for the purpose of promoting physical activity during pregnancy and the position and breathing techniques as a means of non-pharmacological pain relief. This program also reduces anxiety, fear of pain during the delivery, which could increase the possibility of a caesarean section as type of delivery. Qualitative evaluation of the results showed that prenatal exercises and the use of breathing techniques during pregnancy and delivery improved the self-control of pregnant women and reduced the fear of pain, as one of the possible causes of caesarean section (14).

Taking into account the conflicting results of the studies on this topic, further research with a larger number of samples in controlled randomized studies is necessary.

CONCLUSION

Prenatal exercise of moderate intensity has a positive effect on the type of delivery. Even though no statistically significant difference was observed between the groups of pregnant women who exercised and those who did not, the study showed a tendency to increase vaginal delivery in pregnant women who performed prenatal exercise. A natural birth rate increase is achieved with an appropriate prenatal exercise program.

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Original scientific paper

MOTION AND DANCE AS A TYPE OF THERAPY WITH WORKING WITH CHILDREN/PEOPLE WITH DEVELOPMENTAL DIFFICULTIES

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Abstract: Besides the standard treatments that are nowadays used with working with children/people with developmental difficulties and the obligatory aspect of schooling, active free time is also very important for maintaining and improving psychological, motoric and social abilities of children/people with developmental difficulties. Active free time contributes to developing of creativity, satisfaction of one's own life, personality development, and therefore it improves the quality of life itself. The main aim of this research is observation and assessment of motoric abilities of children/people with developmental difficulties, before and after conducting continuous activities in the form of traditional dance i.e. play games as well as the influence on the quality of life. The evaluation of motoric abilities has been done by defectologists before performing an adjusted work program and after completion, in which, using quantitative and qualitative analysis, the progress has been established in segments such as motoric body control, motion coordination of upper extremities, motion coordination of upper and lower extremities and motion coordination of upper and lower extremities by rhythm. Active participation and cooperation between participants, influenced improvement of social skills and the easier overcoming of problems in the group, creative and active free time and improvement of life quality. Based on obtained result, one should strive to adopt new creative ways of working with children/people with developmental difficulties in order to gain comprehensive holistic and rehabilitation approach.

Keywords: children/people with developmental difficulties, free time, life quality, motion and dance.

INTRODUCTION

In recent years, there have been major changes in the lives of people with intellectual disabilities. Changing approaches and methods of working with people with intellectual disabilities have contributed to their more frequent and successful inclusion in the community, as well as involvement in many activities and events that support various aspects of physical, social and emotional development that affect the quality of life in this population. In the past, it was believed that the power of creativity is related to intelligence and that people with intellectual disabilities are not creative due to reduced intelligence. Such thoughts and beliefs have contributed to the fact that people with intellectual disabilities are rarely or not involved in activities that involve various forms of creative expression. Further research and practical experience have shown that people with intellectual disabilities also have creative potential, and that the application of artistic segments (such as movement and dance) can be considered as a good approach in the education and rehabilitation of people with intellectual disabilities. In this regard, the definition of this paper is defined, which refers to the review of previous knowledge on the application and impact of movement and dance therapy on the quality of life of people with intellectual disabilities. Also, present a specific therapeutic program, with a description of the evaluation of the work program of movement and dance therapy on motor skills, movement, emotional and social status.

LIFE QUALITY OF PEOPLE WITH DEVELOPMENTAL DIFFICULTIES

Assessment of life quality of people with intellectual difficulties (ID) is considered to be relatively new area of research in the world, and especially in our climate (Bratković, 2002; Bratković and other,

2006). In general, life quality of people with ID has been examined to a greater extent than subjective life quality from perspective of people with ID. It is important to know objective dimensions so that we could approach easier to subjective dimensions and qualitative research. Seifert has defined six specific interdependent dimensions of life quality when it comes to people with intellectual difficulties:

1. The first dimension includes indicators in the field of habitation by which it analyzes the level of basic needs gratification, a sense of satisfaction, the level of communication and social relationships, competence and independence as well as relation of dependence and autonomy when it comes to connection with residential conditions.
2. The other dimension explains material structure of residential space and area, design of interior and equipment as well as the infrastructure of the environment.
3. The third dimension considers social network that includes people they live with, relatives, friends, acquaintances, neighborhood, but also the presence of support of the experts (educational – rehabilitation workers, psychologists, therapists, caregivers, doctors).
4. The fourth dimension relates to participation in life in general throughout activities and social contacts outside residential area, also including work and free time.
5. The fifth dimension deals with acceptance by the public and comprehension of the social role.
6. The sixth dimension is directed towards workers' satisfaction in direct work with the people with mental retardation when it comes to work conditions, in the rehabilitation concept, professional competence, autonomy and cooperation, satisfaction and burdened, and which can directly reflected to life quality of the people with mental retardation as well as the recipients of their professional help and support. These dimensions act from the core towards periphery, i.e. their influence starts with social relationships within a residential unit (institution or integrated residential unit), starting with material conditions and design of an area to the social relation network that extends even outside of a residential area, and integration or segregation of individuals in a community (Pisaro M, 2017).

A person with ID that lives in a community, usually needs support in two main fields: housing and daily activities, whereby the daily activities can further be described as work activities, free time activities and lifelong learning activities (Rozman B., 2011). Interventions and rehabilitation programs should be directed toward social participation that is the main role and it eases social interaction of people with difficulties (recreational activities, friendship and other), and not only directed to health needs and care. Social participation with children and young adults with ID can improve physical and mental health, increase social participation, independence, a sense of one's own value, and life prosperity as well as entire quality of living (Andrews J. and associates 2014). If we manage to secure life to people with ID that is as similar as possible to cultural standards of their environment, and we provide them with roles and activities that increase their sense of value, there could be an improvement of their lives' quality (Pisaro M., 2017).

Another very important factor that significantly influences life quality of a person is the way a person spends his/her free time. Moreover, it is very important to emphasize that not only the way a person spends his/her free time, but also whether he/she has freedom to choose and make decisions, is one of the main skills of self-determination, in that term. Foremost, a person should have gained self-determination skills (freedom of choice and decision). Once these skills are acquired, it would be possible for a person to apply them in everyday life, without limitations by society. The main characteristic of leisure is free development of personality that indicates the importance of leisure, but also unfolds problem of uncreative spending of every free moment and instead of promoting personality development, further contributes to his/her alienation. The field of leisure is one of the most important features of life quality, a component of

life that contributes to personal well-being. It is a thread that leads to full satisfaction and better life quality, as for an individual, but also for his/her surrounding – a family (Gračanin A., 2020).

APPLIANCE OF MOTION AND DANCE THERAPY

Nowadays, it becomes more popular to see and to use the motion and dance in means of therapeutic purposes. Motion and dance, as they are, became an instrument by which it can be contributed to better and harmonic psychomotor growth of a person. By using the creative therapy, that is art such as dance, one's psychical and physical health can be improved and it also influences quality of life in specific circumstances so that motion and dance are used more and more to soften emotional, cognitive, social, behavioral and physical difficulties (Erdeš N., 2017).

Throughout different anthropological, psychoanalytical, artistic and other interpretation of dance and the symbolism of body movement within dance expression, a possibility of developing diagnostical and therapeutic approaches in different fields has been discovered. The fundamental aim in dance therapy, that is by motion, is working on elements such as awareness, reintegration and improvement of three elements within an individual: picture of yourself, skills of nonverbal communication and a range of quality of emotional experiences (Arandelović M., 2016).

According to basic assumptions of motion and dance therapy, physical movements keep emotional condition of an individual, and changes of motion pattern lead to changes in psychosocial experience. Within this approach the body is a dominant object of therapeutic process, and its change can affect awareness of physiological sensations, physical expression of emotional state, expression of unconscious impulse, creation of new behavioral strategies by discovering new patterns and quality of movements, and by integration of physical, cognitive, emotional and behavioral aspects of a person (Martinec, and associates., 2014).

The therapy by dance rests on establishment of growing problems or eventual limited abilities of an individual that is planned to be included in dance activities. In order to implement the dance therapy, precondition is to respect methodical principles, setting a specific goal, adjusting dance material to average age, psychophysical traits of an individual and encouragement of individualization (Arandelović M., 2016).

The results of series of research have shown that the motion and dance therapy induces feeling for inner structure; reduces impulsiveness; allows one to discover himself/herself; provides satisfaction within himself/herself and raises self-representation; develops feeling for nonverbal signs; develops social skills, sensibility for others, adaptability, partaking, group solving problems, respecting the rules, keeping attention, empathy, inventiveness and partaking in activities, thus it can be considered as an appropriate therapeutic approach in education and rehabilitation of people with intellectual difficulties (Arandelović M., 2016).

In achieving better quality of life of children/people with developmental difficulties, a significant part can be designed for creative content relevant for gaining and perfecting motoric skills and abilities. One of such content is dance that can help in relaxing, balance improving, body coordination, socializing and strengthening of social competencies (Erdeš N., 2017). The inclusion in each class of children of similar ability provides a less stressful environment in which they can relate with their peers and happily encourage each other during the class (López-Ortiz C. and others, 2012). Dance is suitable for children of different ages, and it is also an extraordinary activity for children with different developmental difficulties that often have weaker mobility and coordination (Erdeš N., 2017).

Elements of program of motion and dance therapy that influence improvement of functional, motoric and psychosocial abilities with people that have developmental difficulties

Every therapeutic dance program is structured in a way that participants go through four fundamental learning phases, where each phase can be structured of many specialized exercises and techniques (Dunphy and Scott, 2003):

PHASE 1: warming up,

PHASE 2: awareness of one's own corporeality,

PHASE 3: communication within a group,

PHASE 4: dances.

The main elements of the dance and motion therapy are: warming up, stretching and strength, a session topic, improvisation or solo, relaxation and the end.

Warming up is preparing participants for next activities, both psychically and physically. Usually, warming up while working with people with intellectual difficulties is implemented in a way that participants create a circle. This circle includes all session participants, a leader makes contact with all participants, they accomplish better mutual eye contact, so they can better see and hear each other. Better connection among the members is created within the circle.

Stretching and strengthening is an important aspect directed to supporting physical status of the group members. For the people with high muscle tone, activities for strengthening and stretching muscles are very important, as well as for people with Down Syndrome that usually have low muscle tone. The leader gives the best instructions during guidance of stretching and strengthening muscles throughout demonstration and also shows how some movements are performed. If a person with intellectual difficulties has greater need for supporting and adopting the instructions, it is necessary to include assistant that will help him/her with that. Stretching and strengthening include exercises for neck, shoulders, head, arms, hands, hips and back. The leader always takes care with additional problems of a person with intellectual difficulties so that there would not be any kind of injury. Following exercises of stretching can be performed on the floor or in standing position.

Topic: This is a part of session that requires the maximum attention. Topics have broad description, they can include different concepts starting with some imaginary and improvisational, to learning folk dance. Depending on a group and participants, some participants can start to feel and enjoy the music and start to conceptualize their own moves, while some of them will make a move only when it is demonstrated. Thus, the leader always has to bear in mind individual's needs, motivation and interest.

Improvisation and solo, allow participants to feel free to choose their favorite music or a leader of a group chooses the music that is stimulating for making moves such as marching, jumping and standing. It is especially applicable with children that walk on their toes, so these activities can have a major effect on walk improvement. Likewise, African drums are usually used in these activities because they encourage experience of rhythm and by that even encourage stronger movements. During improvisation, different equipment and materials can be used, such as masks, balloons, drums, etc. When it comes to improvisation, the main focus is development of creativity, self-respect, the right to choose and the development of the personal style. As it is stated, it is not directed towards therapeutic effect, but it can be.

Relaxation can usually be ritualized as the final stage of closing a session. It can serve to restore focus of participants or even reduce uneasiness or tiredness that appeared during the session. The final activities are created depending on group's energy, and a amount of leader's tiredness. (Dunphy and Scott, 2003).

MATERIAL AND METHODS

The research has been conducted in Service Centre "Give us a chance – Zvezdice", which included 21 individuals/children with developmental difficulties at the age of 11 to 26. Each parent/guardian has signed a written consent that they agree that their children are allowed to be part of the research. The research lasted from September 2019 until April 2020. Motoric capability assessment of participants had been done by defectologists at the beginning and in the end of program implementation in order to evaluate progress of motoric and social abilities throughout this work method.

Work program

During six months, the participants of the research were included in a specially designed program in order to include motion and dance throughout traditional dances as a form of therapy in working with children/people with developmental difficulties. The work program alone was structured as per Dunphy's and Scott's program in 2003 where some phases were supplemented with performing motions, steps, segments of traditional dances and songs. The program was performed twice a week for 70 minutes. The main elements of the dance and motion program were: warming up, stretching and strength, a session topic, improvisation or solo, relaxation and the end. The warming up phase included all the participants so that they made a semicircle or a circle, and then a leader of program started to demonstrate warm-up exercises (slow circular movements of head, upper and lower extremities), along with individual help and correction of performed exercises. During the warming up phase, traditional songs were playing in the background so that children with difficulties could get used to the sound alone and to avoid the feeling of fear of the unknown. After the warm-up phase, stretching exercises were performed (the same sequence as with the warm-up phase) and strength exercises in the form of easy squats, endurance during a squat, leaning against the wall, lifting objects weighting 1 kg, with shorter time periods, that later increased. The session phase started with gradual conditional exercises such as running in spot or running in a circle alongside the traditional music rhythms. Afterwards, the leader of the program showed, performed and demonstrated basic elements of dancing patterns of folk dances and customs, along with repeating and exercising these elements (two-step, three-step, hops, turn, dancing in pairs, moving in circle and semicircle, maintenance of "kolo" elements, performance of folk customs). Each new segment was added after three weeks. As the time passed by, more complicated elements were added in order to be performed alongside repeating previously learned patterns. In the relaxation phase for development of creativity, traditional instruments were used, where the participants performed appropriate rhythmic exercises alongside with drum and daf. Everybody was able to choose the way of expressing their personal style. The final phase of the program or the relaxation phase consisted of relaxation methods (on thick mat – relaxation exercises), communications between users or performances of board games by the participants' choices).

The research instrument

The assessment of motoric abilities has been done by certified professional defectologists at the beginning and in the end of program performance (period of six months). Assessment pattern (Practicum for developmental assessment and treatment, Nikolić S., Stosović Ilić D. and Ilić S.) consisted of elemental motions of upper and lower extremities assessment (1 – skilled and accurate, 2 – followed by movements,

3 – elemental motions absence), assessment of ability to maintain balance (1 – is appropriate for an age, 2 – below expected for an age, 3 – above expected for an age), assessment of control of body motor skills (1 – good ability, 2 – bad ability), assessment of motions coordination of upper and lower body extremities (1 – good coordination, 2 – reduced coordination, 3 – without coordination ability), assessment of motions coordination of upper and lower body extremities in rhythm (1 – good coordination, 2 – reduced coordination, 3 – without coordination ability), assessment of melokinetic praxis, ideomotor praxis and ideatory praxis (1 – adequately developed, 2 – inadequately developed, 3 – undeveloped). The obtained results are shown in tables and are statistically done in SPSS program, version 20, alongside using comparative t-test and descriptive methods, and presented in absolute numbers and percentage (values of $p < 0.05$ were considered statistically significant).

RESULTS AND DISCUSSION

In the work program that has been used during the research, 21 individuals with developmental difficulties participated, 10(47,6 %) males and 11(52,4 %) females

According to the data, 3 (14,3%) individuals of the age of 11 to 15, 5 (23,8%) individuals of the age of 16 to 20, 11 (52,4%) individuals of the age of 24 to 25 and 2 (9,5%) individuals of the age above 26, participated in the work program.

Table 1. shows that there was improvement of elements of motoric skills of the included participants. By assessment of elemental motions of upper extremities before program implementation, 28,6 % of the participants had absence of elemental motions of upper extremities, while after finishing the program the assessment value was 14,3 % that proves improvement of skills and abilities in the form of presence of elemental motions of upper extremities followed by movements (table 1). By assessment of motion coordination of upper extremities, 33,3 % of the participants had good motion coordination of upper extremities, 57,1 % had reduced motion coordination and 9,5 % of those respondents were without ability of motion coordination of upper extremities. After finishing motion performance, 61,9 % of the participants had good motion coordination of upper extremities, and 38,1 % had reduced motion coordination of upper extremities. In this segment assessment, there was also improvement of abilities of motion coordination of upper extremities. By assessment of motion coordination of upper and lower extremities before program implementation, it is established that 14,3 % of the participants have good coordination, 76,2 % have reduced coordination and 9,5 % are without ability of motion coordination of upper and lower extremities. The results after program implementation show that 38,1 % of participants have good motion coordination, 57,1 % have reduced motion coordination and 4,8 % of the participants are without ability of motion coordination of upper and lower extremities. By assessment of motion coordination of upper and lower extremities in rhythm before program implementation, it was noticed that 4,8% of the participants have good coordination, 71,4 % have reduce coordination and 23,8 % have no ability of motion coordination of upper and lower extremities. The results after program implementation show that 19.0% of the participants have good motion coordination, 66,7 % have reduced motion coordination and 14,3 % of the participants are without ability of motion coordination of upper and lower extremities. By assessment of ideomotor praxis of participants, within 4,8% of the participants, it is inadequately developed, and within 95,2 % of them, it was completely undeveloped, but after program implementation there was improvement of motion, so that value of ideomotor praxis was reduced to 81,0 %. Ability of ideomotor praxis was undeveloped before program implementation, while after implementation, by all participants value was reduced to 81,0 %.

Table 1. Results review before the program implementation and after the program implementation demonstrated in percentage per assessment of elements of motor skills

ASSESSMENT OF ELEMENTS OF MOTOR SKILLS	Before the program implementation (percent number of respondents)	After the program implementation (percent number of respondents)	p* (comparative t test)
Elemental motions of upper extremities assessment:			
1. skilled and accurate	66.7%	66.7%	0.083
2. followed by movements	4.8%	19.0%	
3. elemental motions absence	28.6%	14.3%	
Elemental motions of lower extremities assessment:			
1. skilled and accurate	66.7%	66.7%	0.715
2. followed by movements	19.0%	19.0%	
3. elemental motions absence	14.3%	14.3%	
Assessment of ability to maintain balance:			
1. is appropriate for an age	23.8%	23.8%	0.042
2. below expected for an age	76.2%	76.2%	
3. above expected for an age	/	/	
Assessment of control of body motor skills:			
1. good ability	42.9%	85.7%	0.016
2. bad ability	57.1%	14.3%	
Assessment of motions of upper and lower body extremities coordination:			
1. good coordination	14.3%	38.1%	0.010
2. reduced coordination	76.2%	57.1%	
3. without coordination ability	9.5%	4.8%	
Assessment of motions of upper and lower body extremities coordination in rhythm:			
1. good coordination	4.8%	19.0%	0.021
2. reduced coordination	71.4%	66.7%	
3. without coordination ability	23.8%	14.3%	
Assessment of motions of upper extremities coordination:			
1. good coordination	33.3%	61.9%	0.002
2. reduced coordination	57.1%	38.1%	
3. without coordination ability	9.5%	/	
Assessment of motions of lower extremities coordination:			
1. good coordination	33.3%	71.4%	0.000
2. reduced coordination	57.1%	28.6%	
3. without coordination ability	9.5%	/	
Assessment of melokinetic praxis:			
1. adequately developed	/	/	/
2. inadequately developed	100.0%	100.0%	
3. undeveloped	/	/	
Assessment of ideomotor praxis:			
1. adequately developed	/	/	0.436
2. inadequately developed	4.8%	19.0%	
3. undeveloped	95.2%	81.0%	
Assessment of ideatory praxis:			
1. adequately developed	/	/	0.402
2. inadequately developed	/	19.0%	
3. undeveloped	100.0%	81.0%	

According to obtained data and the results comparison, with assessment of ability of motoric body control before and after program implementation, statistical significance was obtained $p < 0.016$, which indicates that the elements of work pattern, such as folk dance i.e. the dance where the whole body is moving, affects individual motoric control and requires involvement of all body parts, not only the lower extremities.

Statistical significance $p < 0.02$ was obtained with parallel test of assessment of motion coordination of upper extremities, before and after, where it has been confirmed that activity such as proper posture within circle or in “kolo”, moving in pairs, some folk customs (throwing objects, appropriate dance styles that require movement of upper extremities, usage of carousels) influenced improvement of control of upper extremities motoric and better coordination of motions alone.

By comparing the results of assessment of motion coordination of upper and lower extremities, statistical significance was obtained $p < 0.010$. Folk dance is characteristic because, through all segments of dances and dances' patterns, it requires proper control of the whole body. By using the motion such as circle, semicircle, dance, dancing in pairs (elements of stylized choreographies), the participants' motion coordination of upper and lower extremities has been improved, and with some participants only dancing with other people provided great motivation for mastering appropriate motions and movements.

Throughout the work program alone, along with learning steps, moves, folk dances styles, expressing creativity through traditional songs, the participants performed learned patterns along with listening traditional instruments, so they performed steps alongside the beat of drums in order to develop the sense of rhythm and the speed of the movements. By comparing the results, motion coordination of upper and lower body extremities in rhythm, statistical significance was obtained $p < 0.021$ which shows that the work method used during the program contributed to development of a sense of rhythm, maintenance of different speeds of motions and steps, as well as adjustment of upper and lower extremities according to assigned rhythm patterns and types of motions.

The implemented activities throughout the work program, according to obtained results, showed that it had great impact, not only on motoric abilities and the process of motoric planning of the participants, but as well on social abilities. By using folk dance elements, traditional music, interactive work, performance of folk dances i.e. “kolo” and customs, it resulted in improving some segments of motoric abilities, more precisely the control of body motoric, motion coordination of upper extremities, motion coordination of lower extremities, motion coordination of upper and lower extremities by rhythm, as well as possibility of ideomotor and ideatory praxis.

Reviewing a series of researches, the therapy by motion and dance proved to be as appropriate complementary method within holistic rehabilitation process even for people with intellectual difficulties. Some research indicate that different types of dance such as oriental, traditional Greek dance or social (“community”) dance can influence improvement of motoric skills when it comes to people with intellectual difficulties, that is they can influence their coordination, spatial orientation, lateralization, better body posture and even decrease of body weight. Furthermore, researches indicated that the motion and dance therapy influences socialization and emotional competence that includes improvement of social skills, raising self-awareness level, self-efficiency, self-regulations, motivations, and decrease depression level. By applying the motion and dance therapy, there is an improvement of life satisfaction for people with intellectual difficulties (Arandelovac N., 2016).

The type of such expressive therapy is based on the body and its basic language, movement, and includes its cognition of the body's response. How the whole body gives us a literal and concrete structure of what we do we are, so we can understand the movements of individual parts of the body as a metaphor for the expression of our being. We feel and observe our life through the body. By focusing on your body and expressive language movement, we come to a moment where we can draw from our consciousness, feelings, attitudes, gestures, emotions and direct them to a concrete path. During therapy, people learn how to see and understand the messages that their body gives them without excessive immersion in real problems, that is, what happens in their lives. Focusing being on our body, not only can we nurture consciousness, but,

using movements, we can consciously respond and work creatively with anything that comes out of us. The movement then becomes a metaphor for the way of life of our life stories (Gojmerac, I. and other 2013).

Škrbina and associates claim that by dance activities, thanks to their rhythmic characteristics, aesthetic values and movements of the whole body alongside the music, contributes to development of many motoric skills such as coordination, balance, speed, frequency of movement, endurance and some small amount of explosive power and flexibility. They consider that the dance is one of the most desirable activities when working with children because the dance has the influence on development of a sense of rhythm and motion, a sense of beauty of performing a movement and ability to visualize one's own position in a group. Considering that the natural motion forms are the basis of dance structures, they continuously develop a sense of rhythm, motoric and other abilities of an organism.

Coordination or co-ordinational capacity and motoric planning are developing more through studying process, improvement and practice of motoric knowledge. Within that process it should take into account specific principles so that the progress would be much better. Many reports indicate that the rhythmic activity, especially music, dance or sport helps with motoric planning and sensory integration with successive abilities. Related to this, in quality improvement of motoric function and coordination, space perception, body or body awareness of people, the creative technique such as therapy by motion or dance, combines some elements like motion planning, meaning connection, feelings and attitudes toward planned motion which contributes to creation of new patterns and motion quality, and also contributes to integration of physical, cognitive, emotional and behavioral aspects within people by which, at the same time, encourages motoric planning. (Iverković I., 2013).

The motion and dance therapy can influence several crucial indicators of life quality when it comes to people with intellectual difficulties. On the fundamental level it contributes to physical wellbeing that includes health, mobility and safety. Fitness and mobility are connected by physical abilities and are defined as functional potentials for different activities. Furthermore, it contributes to emotional and spiritual kindness considering that it can have positive effects on emotional and mental state, stress reduction, a sense of self-fulfillment, self-respect and self-confidence. Finally, as motion and dance are socially organized activity, it can also have positive effects on creating and strengthening interpersonal and emotional relationships (Janković Marušić S., 2012).

By using traditional i.e. folk dances, it has shown that it can be useful in fields where body image disorder occurs, or where specific physical or mental limitations inhibit realization of emotional or social needs. It improves motor (motoric planning), social functional abilities, as well as gaining new insights of personal experiences, needs, goals, and encourages social interactions in which this way of work contributes to subjective, emotional and psychosocial kindness, that is improvement of life quality of people with developmental difficulties.

A review of the documents revealed a lack of defined programs, as well as methods that include accurate techniques of dance structures. Lack of description of the use of techniques that diminishes the possibility of using them and creates fear of the unknown during work and activities with people with developmental disabilities. Therefore, it is not possible to include this mode of work as a type of therapy in children with developmental disabilities because of the lack of educational staff or program leaders.

CONCLUSION

Taking into account obtained results and positive effects of applying motion and dance therapy in different problematic areas, as well as importance of organizing free time for children/people with developmental difficulties, it is necessary to form programs in order, not only to improve motoric and social

abilities, but to improve life quality of individuals and their families. By using elements of folk dances, traditional music, interactive work, performing folk dances i.e. “kolo” and customs, by methods that were used in work, it resulted in improving some segments of motoric abilities, more precisely the control of body motor skills, coordination of upper extremities motions, coordination of lower extremities motions, coordination of upper and lower extremities motions by rhythm, as well as possibility of ideomotor and ideatory praxis with participants.

Fulfilled and active free time and satisfaction because of the chosen activities, contribute to creating a sense of fulfillment, self-respect, confidence, building self-importance and reducing stress level. Reduced selection of adjusted programs for work with children/people with developmental difficulties, reduces the possibility of including children/people with developmental difficulties in above mentioned. It is necessary to emphasize the need of designing a program directed towards elaboration of therapeutic programs considering different needs and capabilities of a user, and also considering elaboration of evaluation techniques, measurement instruments and assessment parameters. In that way, it could be pointed to limitations, but also to possibilities of improving structural therapeutic models that would influence the further perspective of applying motion and dance therapy as the standard therapeutic methods with people with intellectual, and other developmental difficulties.

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EFFICIENCY EVALUATION OF HOSPITALS STERILIZATION BY BIOLOGICAL AND CHEMICAL METHODS

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Abstract: Autoclaving is one of the methods which sterilizes medical solidwaste. This study was carried out to evaluate efficiency of autoclaves in two Shahrekord hospitals(Kashani and Hajar) in Iran by biological and chemical indicators. In this study, the performance of autoclave was studied based on biological and chemical through setting 96 tests. Variables were loading type in four groups (light, medium, semi- heavy, and heavy), location, type of hospital, and temperature-135°C, time10min features in fixed pressure equal to 4.2 bar. Biological and chemical indicators were ATCC 7953 which contained *Stearotermophilus Geobacillus* spores, and chemical indicator Class 6 with three color circle as weekly, respectively. The best autoclave operational condition based on biological indicator in both hospitals were light loading rate in Kashani and Hajar 66%(8), and 75%(9) desirable results, respectively. Each four loading rate level based on biological and chemical indicators the Hajar hospital with 68% desirable results were more efficiency than Kashani hospital with 57% desirable results. According to results of this study (biological index) sterilization failure in kashani and Hajar hospitals were 65%, and 50%, respectively. There is an increased need for suitable regulation and control of autoclave devices and for monitoring and suitable handling of these devices in developing countries.

Keywords: Medical solidwaste, Sterilization, Autoclave, Biological indicator, Chemical indicator.

INTRODUCTION

Medical solids waste management is still the most important health and safety challenge in developing countries due to conspicuously inappropriate disposal methods, and insufficient financing and infra-structural challenges (Toktobaev et al. 2015).

Medical solids waste treatment technologies include thermal processes, chemical treatment technologies, autoclaves, integrated steam-based treatment systems, microwave treatment technologies, dry-heat treatment technologies, irradiation treatment, biological processes, mechanical treatment processes, and incinerators. The most benefit of autoclaves is that they cost less than traditional medical solid waste incinerators. Steam sterilization inactivates microorganisms through heat generated by the saturated steam (Rutala and Weber 2015). An autoclave consists of a metal chamber surrounded by a steam jacket. Steam is introduced into the outside jacket and the inside chamber. A common contact temperature–time factor is 121°C and pressure 2 bar for 30 min or above 134°C and 3.1 bar time 5 min (Maamari et al. 2016). A number of tools are available to assess the performance of the autoclave; these include physical, chemical and biological indicators. Physical indicators: Temperature and pressure recording devices such as thermocouples can be put inside the load to specify the temperature obtained in the bag itself. Chemical indicators are used in the autoclave sterilization of biomedical waste. When the sterilization is completed, color change must be detected in the chemical indicator carrier that has been autoclaved together with the waste. Biological indicators are used in the efficacy testing of the autoclave process to effectively sterilize the contents being

treated. A common microbial inactivation standard for Health Care Waste treatment based on the State and Territorial Association in Alternative Treatment Technologies (STAATT) criteria is Level III, i.e. inactivation of vegetative bacteria, fungi, lipophilic/hydrophilic viruses, parasites and mycobacteria at a $6 \log_{10}$ reduction or greater; and inactivation of *Geobacillus stearothermophilus* (Bs) spores and *Bacillus atrophaeus* spores at a $4 \log_{10}$ reduction or greater (Datta et al. 2018; Lemieux et al. 2006). In the recent years, many researches were conducted to hospital waste management in Iran and other countries around the world (Kulikowska et al. 2019; Rafiee et al. 2016; Winter et al. 2017; Wojnowska-Baryła et al. 2019). Deficiency to sterilize medical equipments properly presents a risk of healthcare-associated infections (Panta et al. 2019a). The average general waste production rate was 2.12 ± 0.37 kg/bed/day at Shahrekord hospitals (Sadeghi et al. 2020). According to other studies, amount of medical solid waste generation in Iranian hospitals is between 1.92 to 4.4 Kg/bed-day and 10.5% to 34.5% are infectious wastes (Farshad et al. 2014; Hossain et al. 2012). Solid waste production per capita in other countries such as Brazil, Jordan, France, Spain and Portugal is 2.63, 3.41, 2.5, 3 and 1.4 Kg/bed-day respectively, which 85% of this is nonhazardous and remaining 15% is hazardous (Farshad et al. 2014; Miranzadeh et al. 2012). In last thirty years, the most Iranian hospitals were installed incinerator for disposal of infectious waste. Disadvantages of incinerator are high initial cost, air pollution, operation and maintenance problems and the need of trained personnel for operation. For this reasons, incinerator is discarded (Miranzadeh et al. 2012; Sadeghi et al. 2020). Recently health, cure and medical education administration suggest application of steam autoclaves for immunization of hospital infectious wastes, so several cases of this set was installed in hospitals of Iran. The primary objective of this study was to evaluate efficiency of autoclaves in Shahrekord hospitals. The secondary objective of this study was to investigate the time, pressure, and temperature dependence of loading type.

This study was carried out to evaluate study on the operation management of medical solid waste autoclaving disposal facilities, variables were loading type in four groups (light, medium, semi-heavy, and heavy), location, type of hospital, and temperature-time.

METHODOLOGY

STUDY AREA

This research was implemented in two hospitals (Kashani and Hajar) in Shahrekord in southwest, Iran with a population of 190,441 people (2016). This study was performed in laboratory School of Health, Shahrekord University of Medical Sciences during 2018. Selection of hospitals was based on their bed and type of treatment technologies used for waste disposal. Table 1 shows the hospital specifications and their waste disposal equipments. Both hospitals had same autoclaves (Table 1).

The average health-care waste generation in Shahrekord hospitals is 900 to 1000 kg/day. Total medical solid waste were 63% general, 36.05% were infectious wastes while 0.18% were sharps, 0.1% were chemical and pharmaceuticals, 0.1% were pathological wastes, 0.02% were radioactive. The composition of the generated waste was found to be $16.6 \pm 1.44\%$ paper, $18.8 \pm 2.35\%$ plastic, $4.9 \pm 0.27\%$ glass, $16.5 \pm 1.01\%$ textile, $0.87 \pm 0.03\%$ metals, $24.7 \pm 2.35\%$ food waste, and $17.63 \pm 1.91\%$ other (Sadeghi et al. 2020).

Table 1. Characteristics of hospitals and the devices they used for waste disposal

Hospital	Number of active beds	Total generation rate (kg/bed-day)	Type of device
Kashani	330	1.94	Autoclave without shredder
Hajar	290	1.85	Autoclave without shredder

STERILIZATION PROCEDURE

The performance of subjected autoclave was studied based on biological index and chemical indicator through setting 96 tests. Variables of both autoclaves were temperature-135°C, time duration-10min were and pressure(4.2 bar) fixed. Loading type are grouped in four groups: (light, medium, semi- heavy, and heavy). Light loading rate: equal to 25% or lower than 25% volumetric capacity of autoclave, medium loading rate: 45 to 50% volumetric capacity of autoclave, semi- heavy loading rate: 70 to 75% volumetric capacity of autoclave, and heavy loading rate: equal to 95% or higher than 95% volumetric capacity of autoclave. Microbial analysis of waste residue was performed based on the guidelines of the Iranian Ministry of Health and Medical Education (Farshad et al. 2014). ProSpore2 (a self contained biological indicator) containing 10^6 spores of *Geobacillus stearothermophilus* ATCC7953 was used to test the efficacy of devices in disinfecting the waste residue. ProSpore2 consists of a paper disc carrier with *Geobacillus stearothermophilus* (ATCC 7953) spores. The disc is in a plastic tube with a glass vial of growth media for the bacterial spores. Bromocresol purple (a pH detector) was added to detect spore growth. The growth of spores decreases pH and changes the color purple to yellow after a 24-hour incubation period (Farshad et al. 2014; Fraiha et al. 2010). The biological indicator in the test trial was placed in a horizontal as possible, as recommended by the manufacturer. At the end of cycle, the ProsPore2 indicator was cap sealed. The glass ampoule of media was crushed and the *Geobacillus stearothermophilus* disc was contaminated. Figure 1 showed that biological indicator. Vials were then incubated at 55°C for 48 hours. If the ProsePore2 biological indicator retained its purple color (Figure 1(a)), it showed an adequate sterilization cycle and if it signed turbidity or a color change toward yellow for that sterilization cycle, it explained insufficient of sterilization and the chance of microbial pollution (Figure 1(b)). In each round, untreated ProsPore2 biological indicators were incubated as controls (Datta et al. 2018). Chemical indicator Class 6 with three color circle as weekly. Figure 2 showed that chemical indicator: (safe, optimum, and failure). For description of chemical indicator test, “Optimum” and “Safe” status regarded as desirable sterilization.

STATISTICAL ANALYSIS

Descriptive statistical parameters, such as the mean ,percentage, median, minimum and maximum, were applied to the data. Data was coded and analyzed using SPSS 16 software.



a. Pass/ sterilization



b. Fall/unsterilization

Figure 1. Biological Indicator (a. pass, and b. fall)

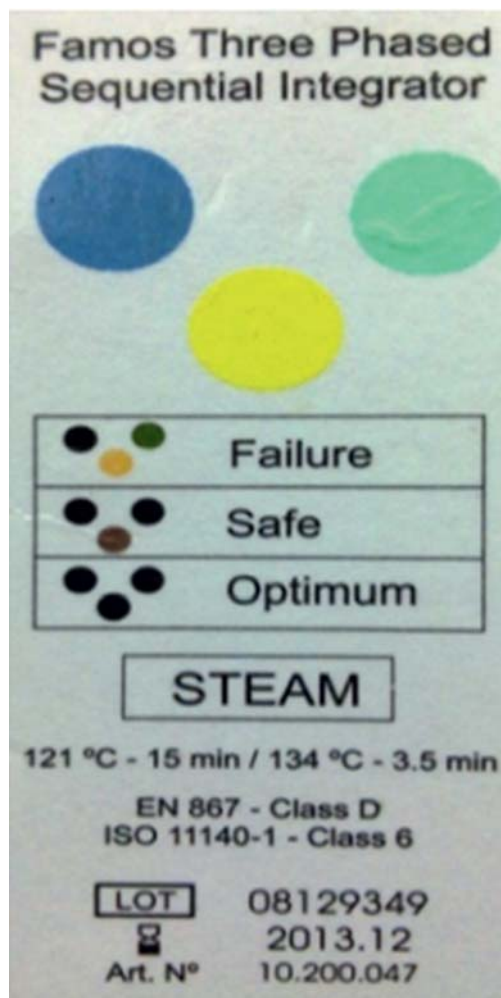


Figure 2. Chemical indicator (safe, optimum, and failure)

RESULTS

Table 2. showed that status biological indicator of hospitals, and Figure 3. Shows that status the number of sample based on biological indicator in hospitals. The best autoclave operational condition based on biological indicator in both hospitals were light loading rate in Kashani and Hajar 8 of 12 (66%), and 9 of 12 (75%) desirable results, respectively (Table 2). Each four loading rate level the Hajar hospital with 24 of 48 (50%) desirable results were more efficiency than Kashani hospital with 17 of 48 (35%) desirable results (Table 2 and Figure 3). Figure 4 shows that status the number of sample based on chemical indicator in hospitals. Table 3 showed that status chemical Indicator of hospitals. The best autoclave operational condition based on chemical indicator in Kashani hospitals was light loading rate 100% desirable results (Table 3), and Hajar hospitals was light loading rate and medium loading rate 12 of 12 (100%), and 12 of 12 (100%) desirable results, respectively. Each four loading rate level the Hajar hospital with 41 of 48 (85%) desirable results were more efficiency than Kashani hospital with 38 of 48 (79%) desirable results (Table 3 and Figure 4). Figure 5 shows that status the number of sample based on biological and chemical indicators in hospitals. Each four loading rate level based on biological and chemical indicators the Hajar hospital with 65 of 96 (68%) desirable results were more efficiency than Kashani hospital with 55 of 96 (57%) desirable results (Figure 5).

Table 2. Status biological indicator of hospitals

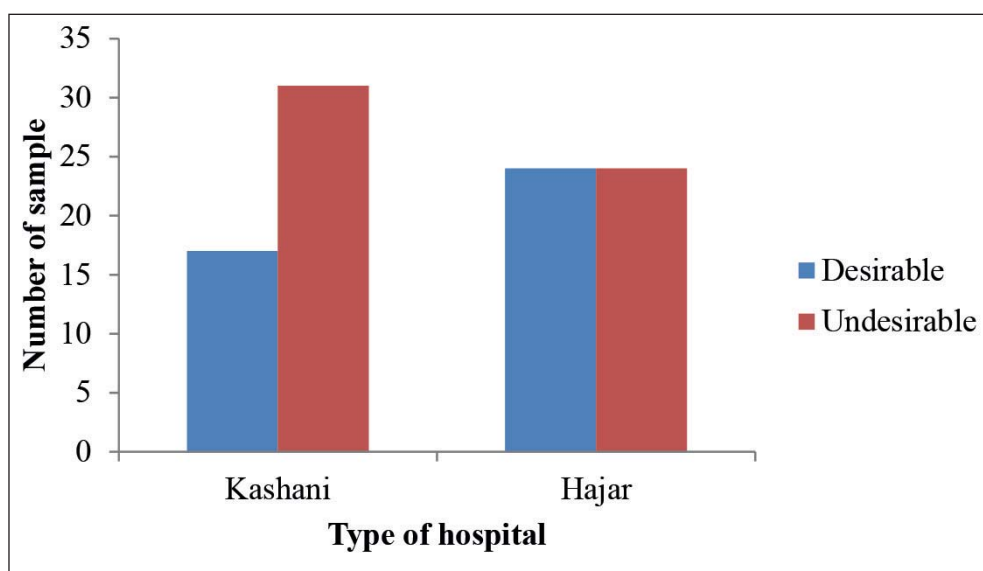
Type of loading	Kashani				Hajar			
	Desirable		Undesirable		Desirable		Undesirable	
	Number	%	Number	%	Number	%	Number	%
Light(N=12)	8	66	4	46	9	75	3	25
Medium(N=12)	6	50	6	50	8	66	4	46
Semi-heavy(N=12)	3	25	9	75	5	41	7	59
Heavy(N=12)	0	0	12	100	2	16	10	84
Total=48	17	35	31	65	24	50	24	50

Pressure equal to 4.2 bar, temperature-135°C, time10 min,Desirable=no microbial growth, undesirable= microbial growth

Table 3. Status chemical indicator of hospitals

Type of loading	Kashani				Hajar			
	Desirable		Undesirable		Desirable		Undesirable	
	Number	%	Number	%	Number	%	Number	%
Light(N=12)	12	100	0	0	12	100	0	0
Medium(N=12)	11	91	1	9	12	100	0	0
Semi-heavy(N=12)	8	66	4	46	9	75	3	25
Heavy(N=12)	7	58	5	42	8	66	4	46

Pressure equal to 4.2 bar, temperature-135°C, time10 min Desirable=no microbial growth, undesirable= microbial growth

**Figure 3.** Status the number of sample based on biological indicator in hospitals

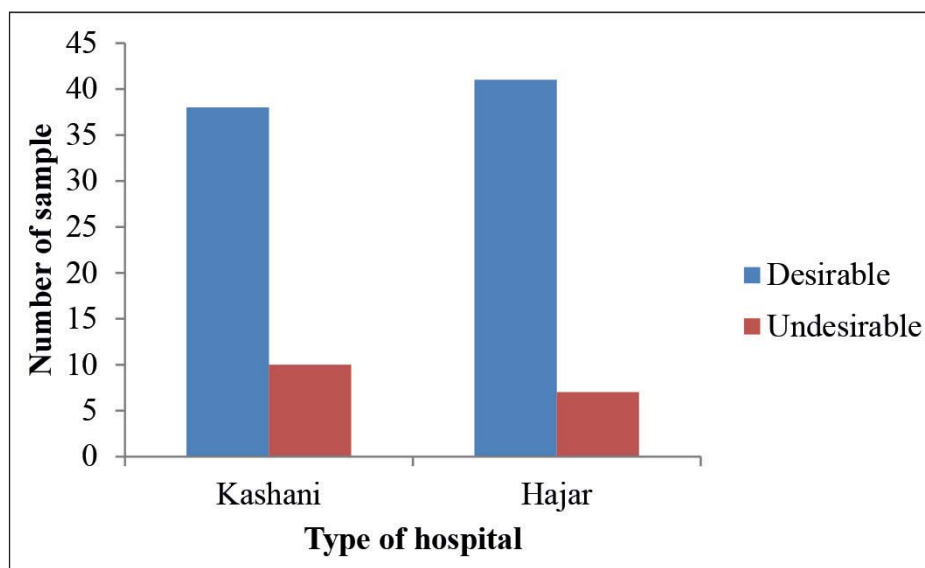


Figure 4. Status the number of sample based on chemical indicator in hospitals

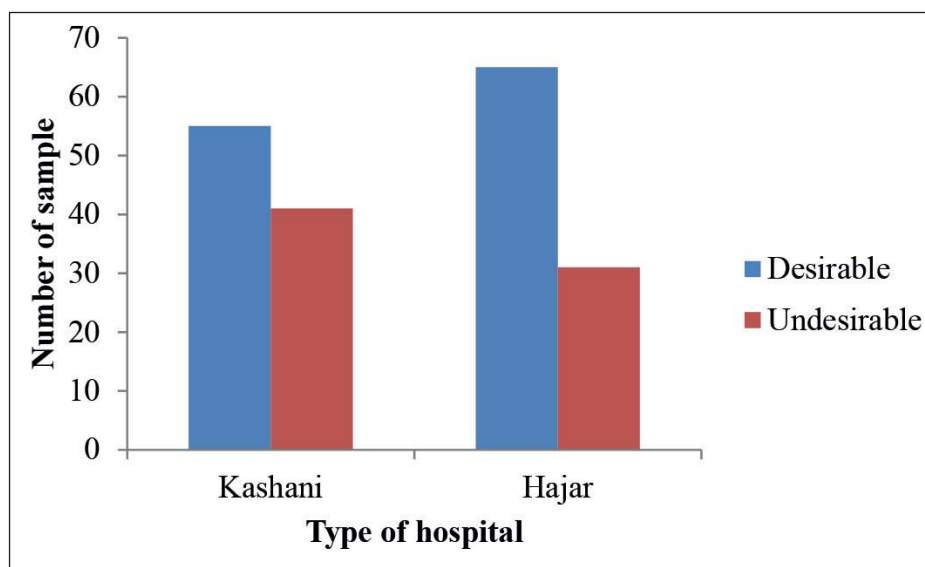


Figure 5. Status the number of sample based on biological and chemical indicators in hospitals

DISCUSSION

This study was carried out to evaluate efficiency of autoclaves in two Shahrekord hospitals by biological and chemical indicators. Based on the results of this research, the best autoclave operational condition for sterilizing medical solid wastes are: Light loading rate lower than 25% and temperature-time equal to 10min-135°C in fixed pressure of 4.2 bar, respectively. Another study conducted to evaluate the best condition for sterilizing medical solid wastes are: temperature-time equal to 15 min-134°C and 10min-140°C in fixed pressure of 101 kPa (Miranzadeh et al. 2012). Another study reported that tests on autoclaves in undesirable results, with bacterial growth occurring in 18 of 22 ampules, and chemical indicators failing in 19 of 22 locations (Hossain et al. 2012). Another study reported that STAATT method, acceptable technology for treating medical solid waste must reach inactivation level III, which is a 6Log_{10} reduction for the vegetative bacteria (Hossain et al. 2012).

Another study found that 84% autoclave cycles performed using factory default settings failed to sterilize the biological indicators in the center of the load (Garibaldi et al. 2017). This included all runs

performed using a liquid or gravity cycle for 30 min or a vacuum cycle for 15 min at 123°C or 134°C, respectively (Garibaldi et al. 2017). According to results of this study (biological index) sterilization failure in Kashani and Hajar hospitals were 65%, and 50%, respectively. The results of this research (chemical index) showed that sterilization failure in Kashani and Hajar hospitals were 21%, and 15%, respectively. A few studies that have evaluated the effectiveness of autoclaving in different countries. Studies in Kenya, India, Canada, UK, and Mexico showed (12%, 31%, 2.3%, 1.5%, and 21% respectively) of sterilization failure (Panta et al. 2019a). One study reported that autoclave cannot be considered as an alternative technology to disposal in clinical solid waste management (Hossain et al. 2012). Another research found that 71% of biological indicators remained non-sterile after exposure to sterilization processes in hospitals in Nepal (Panta et al. 2019b). Sterilization efficiency is dependent upon many variables that affect the physics of heat transfer and steam infiltration, including the waste load, composition, weight, liquid content, and types of reservoirs. Biological and chemical indicators the Hajar hospital desirable results were more efficiency than Kashani hospital, for this reasons: lack of staffs training, high loading volume, and position of the load within the autoclave chamber in Kashani hospital (Farshad et al. 2014; Hossain et al. 2012). The Standard Operating Procedures (SOP) for the autoclave unit, and training should be provided for any new autoclave operators.

Finally, autoclaves need to be operated and tested on a regular basis to ensure that they achieve the suitable pressure, time, and temperature before being used for patient care. Recommends that the following adjustments to policies and practices be implemented in order to better achieve sterilization and ensure proper maintenance for each autoclave:

- a. Reregulation of cycle times: The standard 121°C, 1.05 bar, and 15-minute contact time are sufficient for sterilization.
- b. Proper autoclave use: The autoclave bag should never be over-packed or sealed too tightly.
- c. Record keeping: The use of an autoclave logbook is recommended for each autoclave.
- d. Safety maintenance: General maintenance should be conducted on an annual basis or as recommended by the manufacturer.
- e. Training: Each autoclave user should be trained on the proper use of the autoclave (Le et al. 2005).

CONCLUSIONS

It was shown in this study that the biological and chemical indicators were investigated for the effectiveness of steam on bacteria during the sterilization process. It was observed during this study that the steam autoclave performed most effectively at a contact time of 10 min, a temperature of 135°C, and at a pressure of 4.2 bar, to inactivate *Bacillus stearothermophilus*. Each four loading rate level based on biological and chemical indicators the Hajar hospital with 65 of 96 (68%) desirable results were more efficiency than Kashani hospital with 55 of 96 (57%) desirable results. This study may alarm other developing countries to possible defects in autoclave performances and provide a method. There is an insist need to improve autoclave processes in both hospitals. There is a need for awareness of medical solid waste management amongst the patient and worker in order to prevent nosocomial infection and environment hazards. Policy and regulation guidelines must be prepared to all of the hospitals through out the Iran as also recommended in Shahrekord.

Management of medical waste in the Shahrekord, and Iran has shown positive signs of improvement in recent years. This improvement has been demonstrated through national medical solid waste legislation, and the establishment of a centralized controlled autoclaving and incineration facility for treating hazardous and infectious medical solid wastes.

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TRENDS IN AIR POLLUTION: THE USE OF MOSSES AS BIOMONITORS

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Abstract: Air pollution is a major concern throughout the universe due to the effects on living and non-living things. Before an area is said to be polluted, there is the need to carry out a bottom-up or top-down assessment of the environment. Mosses have been widely employed as cheap bioindicators of atmospheric pollution. It reduces the time-frame spent in monitoring and the results are reliable. Several types of research have been undertaken on the spatial and temporal trends in air pollution using mosses. This paper explained what moss is, discussed the cost of biomonitoring using a moss, mapping, and researches undertaken on mosses as bioindicators.

Keywords: Pollution, mosses, Bryophyta, *Orthotrichum lyellii*, cheap biomonitor, mapping, elements.

INTRODUCTION

There is an attendance problem world over due to air pollution. The major increase in housing, vehicular movements, industrial activities and farming, paved and unpaved roads have increased air pollution. The resultant effects have affected lives (health-wise, even death) and material things (destruction). The air pollution is one of the world's largest environmental health risks. World Health Organization (2014) estimates that air pollution is contributing to about 7 million premature deaths annually. The presence of organic and inorganic chemicals, particulates or biological material in the air has also produced atmospheric pollution. Several effects of air pollution are of global concern, with climate change and stratospheric ozone depletion, being the most serious environmental issues (Ristić *et al.*, 2013).

The atmosphere, hydrosphere, lithosphere, and biosphere are major environmental compartments or conceptual spheres where the flow of matter and energy takes place within every sphere and also between each of them in both directions (Figure 1). Abiotic and biotic processes that take place in the compartments are known to be responsible for the conversion of matter and energy which in turn make the system more complex and influence the distribution and flow of matter and energy (Ristić *et al.*, 2013).

Environmental awareness is increasing both in developed and developing countries. Chemical monitoring has been used to identify pollutants. The method is fascinating because it's so expensive to monitor air because of the time was taken and finance involved. Biomonitoring using lichens, mosses and plants are taken as an alternative method to this. Biomonitoring using these organisms are considered cheap. Mosses are considered reliable indicators of air pollution to ecosystems simply because they get most of their nutrients directly from the air, rain, rather than the soil (Phillips, 2016).

Instrumental and chemical monitoring methods lack information on the effects of atmospheric pollutants on the living organism and hence, there has been an increasing interest in using indirect monitoring methods based on a response of living organisms that may act as trace element bioaccumulators (Ristić *et al.*, 2013; Reski, 2012).

In this paper, we review the application of mosses as biomonitors of various pollutants and their sources in the environment.

WHAT IS MOSS?

Mosses are flowerless plants that grow (0.2–50 cm high) mainly in dense green clumps or mats, damp or shady places. They are composed of simple, one-cell thick leaves that are attached to a branched or unbranched stem that conducts water and nutrients (Hubers and Kerp (2012). The flowerless plants do not possess seeds and when fertilized, they develop sporophytes gametophyte and a sporophyte stages). The spore capsule, often with a supporting stalk (sporophyte and gametophyte stage.). Mosses are classified into division Bryophyta which has eight classes (Figure 1).

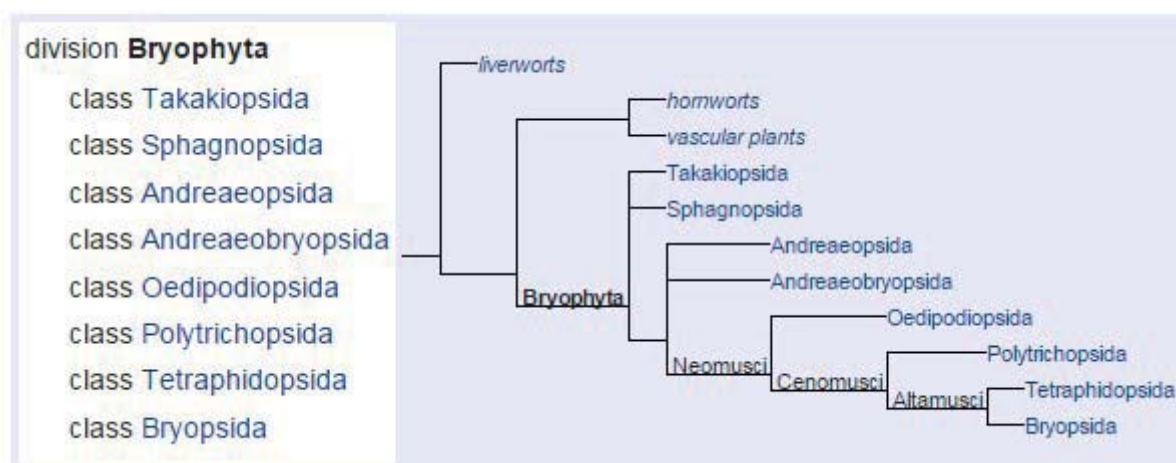


Figure 1. Classes of Bryophyta

Moss has a fairly weak stem which is fairly short when standing erect (tufty growth form) and the other growth form (trailing) which makes the moss look like a creeping plant. Moss has rhizoids. They are anchoring structures, root-like, which has non-absorptive functions of true roots. Different moss parts possess different types of leaves according to the growth form (Australian Natural Herbarium (2012).

COST OF MONITORING

According to Harmens (2010), monitoring pollutants in rainwater or airborne particles samples require frequent sampling and is expensive, according to them, monitorings are only done at a limited number of locations across Europe. On the other hand, mosses sampling is relatively cheap, they can be obtained from many locations in Europe, and scientists can get useful information by sampling them just every five years. The heavy metals analysis for moss costs them \$50 per site, a low cost that makes it possible to sample extensively. In the study of Gatzolis *et al.* (2016), it was noted that the determination of pollutants in bioindicator costs less than using instruments, using moss samples cost about \$150 for laboratory analyses and manpower.

The United States researchers from the Forest Service have turned to the use of cheap ally (moss). The researchers gathered 346 samples of *Orthotrichum lyellii* moss grown on the trunks of hardwood trees in Portland, from locations around the city and were analyzed for their concentrations of cadmium, arsenic, and selenium cations (DeWeerd, 2016).

BIOMONITOR

Moss is a superb air pollution monitor because it gets all of its water and nutrients from the atmosphere, storing whatever compounds happen to be present in the local environment. A final version of the United States Forest Service (SFS) study published on April 7 in *Science of the Total Environment* says that while moss has been used as “bioindicators” by the Forest Service and other agencies for decades, this was the first time it’s been used to generate a detailed map of air pollution in a city.

The cadmium portion of the moss study revealed that moss is an effective bioindicator of cadmium levels in the air (Donovan *et al.*, 2016b).

Moss has been used by Sweden researchers to detect air pollution in forests since the 1960s Donovan *et al.* (2016a). Moss doesn’t have roots; it’s like a sponge, absorbing moisture, and nutrients from the air, as well as contaminants. These contaminants are stored in the moss tissues, making them a living record of pollution levels in the surrounding environment. Because some species of moss are very sensitive to air pollution, they are indicators of good or bad air quality. If certain sensitive species are declining, it’s an indication that the air quality is declining.

MAPPING

Moss is a low-cost way of mapping air pollution and has the potential to revolutionize the enforcement of environmental regulations. In 2013, a team of the United States scientist, Jovan and Donovan of Forest Service’s Pacific Northwest Research Station in Portland, Oregon embarked on a research on pollution using moss samples, this lead to a detailed and rigorous mapping of air pollution in a United States city. The study showed that moss can serve as a low-cost screening tool to help cities strategically place their expensive and limited instrumental air-quality monitors (Sands, 2016).

PREVIOUS STUDIES ON AIR POLLUTION USING MOSSES.

Vuković *et al.* (2015a), studied the level of air pollutants in 16 polycyclic aromatic hydrocarbons (PAHs), and 41 major elements, trace elements, and REEs using *Sphagnum girgensohnii* moss bag method. From the results obtained, it was observed that the moss under investigation had concentrations of PAHs, Sb, Cu, V, Ni, and Zn cations, while the moss had the same REE concentrations of North American Shale Composite and Post-Archean Australian Shales due to anthropogenic activities. The results clearly demonstrated the seasonal variations in the moss enrichment of the air pollutants.

Vuković *et al.* (2016), studied the harmful effects of human long-term exposure to intense traffic emissions in the urban area of Belgrade (Serbia) using moss bags (*The Sphagnum girgensohnii* and *Hypnum cupressiforme*). Forty-eight locations were monitored for a period of 10 weeks. Concentrations of 39 elements were determined. The results obtained depicted that the exposed moss bags were enriched with Sb, Cu, and Cr. It was concluded that concentrations of each elements were dependent on traffic emissions.

Špirić *et al.* (2014), worked on four moss species (*Hypnum cupressiforme*, *Pleurozium schreberi*, *Homalothecium sericeum* and *Brachythecium rutabulum*). The aim was to biomonitor air pollution with Hg in Croatia using cold vapour atomic absorption spectrometry (CV-AAS) method. From the results obtained, mercury ranged from 0.010 to 0.145 mg kg⁻¹ with a median value of 0.043 mg kg⁻¹. The Hg distribution map showed the sites of the country with high levels of this element.

Gatziolis *et al.* (2016), measured twenty-two elements using moss samples obtained in Portland, Oregon with the view of developing citywide maps depicting concentrations of metals in moss and identifying possible air pollution. The results showed that 15 metals which included Cd, Ni, Pb, and As cations

were highly right-skewed distributed. It was recommended that constant monitoring should be ensured to determine whether the hotspots pointed out by the moss indicator pose a health risk.

Vukovic *et al.* (2015b), explored the suitability of the moss *Sphagnum girgensohnii* for biomagnetic monitoring in the cities of Belgrade. *S. girgensohnii* moss bags were exposed at three different microenvironments characterized by heavy traffic. The ferro(i)magnetic PM fraction in the moss samples was quantified by Saturated Isothermal Remanent Magnetization (SIRM) and the measured values were compared with the trace element concentration in the moss samples. The results showed that SIRM values were significantly different across the considered urban microenvironments, but a high correlation between moss SIRM values and concentrations of Al, Ba, Co, Cr, Cu, Fe, Ni and Pb cations was found. The results showed that moss bags can be used for biomagnetic monitoring spatial-temporal distribution trends in air pollution.

In another study, Donovan *et al.* (2016b) identified unknown sources of Cd pollution in 346 samples of the moss *Orthotrichum lyellii* from deciduous trees using a modified randomized grid-based sampling strategy across Portland, Oregon. The results of the maps showed very high concentrations of Cd around the two stained-glass manufacturers. The monthly average atmospheric Cd value was 29.4 ng/m³, which was 49 times higher than Oregon's benchmark of 0.6 ng/m³, which was high enough to pose a health risk.

Lazi *et al.* (2016), in urban street of Canyon in Belgrade (Serbia), investigated the air pollutant distribution using the moss bag. Operational Street Pollution Model (OSPM) was used to predict the contents of NO_x, NO, NO₂, O₃, CO, BNZ, PM₁₀ and trace elements. The results of both methods, modeling, and biomonitoring, showed significantly decreasing trend of air pollutants with height. The results showed that the moss bag technique could be a valuable tool to verify model performance.

Vukovic *et al.* (2014), studied the PAHs and Al, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr and Zn cations in PM10 samples obtained in Belgrade, Serbia. The metals were determined in the biomonitor earmarked for the sampling (*Sphagnum girgensohnii* moss bags). The results obtained showed that concentrations of PM10, Cd, Ni, and B[a]P exceeded the European Union guidelines. Further research was recommended on the use of *S. girgensohnii* moss bag technique to determine its suitability in indoor pollution monitoring.

Deljanin *et al.* (2013), studied an active moss biomonitoring survey of lead isotopic composition in the Belgrade urban area. Samples of the moss *Sphagnum girgensohnii* were used for the study. The results showed ²⁰⁶Pb/²⁰⁷Pb isotopic with a ratio of 1.167-1.184 for samples at 4 m height, and 1.164-1.184 at 8 m height and ²⁰⁸Pb/²⁰⁷Pb isotope with the ratio of 4 and 8m height, which was in the range 2.450-2.477 and 2.433-2.471, respectively. The results for moss bags exposed at both heights indicated that Pb still presents in the environment.

Goryainova *et al.* (2016), used *Sphagnum girgensohnii* moss bags to determine the small-scale vertical distribution of some major and trace elements in different types of street canyons (regular, deep and avenue types) in Belgrade and Moscow urban area using neutron activation analysis. The results showed that the accumulation of elements in the exposed moss bags was much in deep and regular street canyons when compared with that of the avenue type, the latter even with the higher traffic flow. It was deduced that *S. girgensohnii* was sensitive to small-scale variations of the total concentrations of elements.

In a study from Mahabaleshwar, India, Chakraborty *et al.* (2004) studied the metal compositions of two moss samples obtained from a remote hill station using an Energy Dispersive X-ray Fluorescence instrument (EDXRF) and Instrumental Neutron Activation Analysis (INAA) techniques. They recorded the abundance of the cations as Al, Sr, Zn, and Rb. All the metals were enriched in the soil samples.

Macedo-Miranda *et al.* (2016), also contributed to the study of air pollution using moss samples (*Fabriona ciliaris* and *Leskea angustata*) obtained from the Toluca Valley (MATV) in Mexico. The team

used Absorption atomic spectrometry analysis (AAS) for the determination of the cations (Cr, P, Cd, and Zn). The results obtained depicted that the average metal concentrations in the mosses were in the order of: $Zn > Pb > Cr > Cd$. It was noted that the concentrations of heavy metals were higher in *Fabriona ciliaris* than *Leskea angustata*. The study concluded that the enrichment of the metals were higher in the raining season and also the metals were suggested to be from an anthropogenic sources.

Jiang *et al.* (2018), in their study compared the metal accumulation power of mosses and vascular species from urban areas and quantified the suitability of the two for monitoring airborne heavy metals. The samples were obtained from the urban area of Wuhan City, Hubei Province, China. The cations determined were Ag, As, Cd, Co, Cr, Cu, Mn, Mo, Ni, V, Pb, and Zn using inductively coupled plasma mass spectrometry. The differences of heavy metals concentration in the samples depicted that the moss species accumulated the heavy metals than tree leaves (3 times to 51 times). The accumulation of heavy metals in the moss samples depended on the metal species and land.

In the Republic of Macedonia, moss surveys (2005 and 2015) was carried out by Stafilov *et al.* (2018). Over 72 samples of the terrestrial moss samples were obtained. Inductively coupled plasma-atomic emission spectrometry (ICP-AES) and atomic absorption spectrometry (AAS) were used to determine 22 elements (Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Rb, Sr, V, and Zn). Comparing the results from the surveys, it was found out that nearly all the potentially toxic elements (As, Cd, Co, Cr, Cu, Ni, Pb, and Zn) increased in concentration in moss samples from 2002 to 2005 but decreased in the samples from 2010 to 2015.

Allajberu *et al.* (2017), used *Hypnum cupressiforme* and *Pseudoscleropodium purum* collected from 44 locations to characterize the toxic metals and metalloids in Albanian air. Inductively coupled plasma-atomic emission spectrometry (ICP/AES) and epithermal neutron activation analysis (ENAA) was the instrumentation used. The results obtained showed that both contamination factors (CF) and pollution loads index (PLI) were depicted at a moderate to high pollution scale. the potential ecological index (RI) results depicted the presence of a high ecological risk. The was potential risk of human exposure to trace metals, especially in the areas with the highest element concentrations.

Bačeva *et al.* (2012), studied the atmospheric deposition of elements in Kavadarci, Republic of Macedonia using moss biomonitoring. The study also determined the possible sources of pollution. In the study network of mosses (31 samples) distributed over 600 km² was used. A total of 46 elements were determined by mass spectrometry with inductively coupled plasma (ICP-MS). From the results, according to the distribution pattern of elements determined in the samples, two anthropogenic geochemical associations (Co-Cr-Cu-Fe-Mg-Ni and As-Cd-Cu-Hg-Pb-Zn), were detected. The enrichment ratio confirmed the influence of the dust from the ferronickel plant to the air pollution in this region.

De Agostini *et al.* (2020) analysed the results of a biomonitoring campaign, carried out with *Hypnum cupressiforme* Hedw. moss bags near an oil refinery, situated at the southwestern part of Sardinia island (Italy). The study was based on the effects of rainfall and distance from the source of contamination of 14 trace elements measured over 16 years and to show any increasing or decreasing trends, as well as any peak in presence of airborne pollutants in the area. The annual elements' concentration values were plotted and discussed. The study concluded firstly, that the location of the source of contamination and the rainfall influenced the elemental concentration in the biomonitor in the case study differently, due to the element determined and on the exposure condition, secondly, the bag that contained *H. cupressiforme* provided relatively stable measurements during the 16-year time frame, and thirdly, similar conditions of exposure determined less variable accumulation values.

Gaza and Kugara, (2018), determined the heavy metals pollution of the University of Zimbabwe, Harare, Zimbabwe environment using *Grimmia dissimulate* moss bag. The moss was subjected to heavy

metals analysis using Atomic Absorption Spectroscopy. The concentrations were expressed as Relative Accumulation Factors (RAFs) and the means for Cr, Cu, Pb and Zn were 14.38; 18.17; 9.63 and 10.78 respectively. The results showed the concentration order of deposition was Cu > Cr > Zn > Pb and that Zn deposited.

CONCLUSION

Mosses have been regarded as a useful method in biomonitoring. It is an effective screening tool in environmental pollution. It is an inexpensive alternative to the use of an instrument that has provided valuable information on pollution. The results obtained by all the researchers have been used in formulating policies that are used in mitigating the environmental pollution of both developed and developing countries. It saves time in a situation where monitoring instruments need more than a month, moss will provide results for a single location. It is also a good tool for mapping (provision of hotspots) in air pollution.

Table 1: Previous studies on biomonitoring using mosses

S/N	Mosses used	Parameters	Location & Year	References
1	<i>Sphagnum girgensohnii</i> trace elements, and REEs	16 polycyclic aromatic hydrocarbons moss bag (PAHs) 41 major elements	Belgrade, Serbia, 2015	Vuković et al. (2015a)
2	<i>Sphagnum girgensohnii</i> and <i>Hypnum cupressiforme</i> moss bags	39 multi-elements	Belgrade, Serbia, 2016	Vuković et al. (2016)
3	<i>Hypnum cupressiforme</i> , <i>Pleurozium schreberi</i> , <i>Homalothecium sericeum</i> and <i>Brachythecium rutabulum</i>	Hg	Croatia, 2014	Špirić et al. (2014)
4	<i>Orthotrichum lyelli</i> Hook	22 multi-elements	Portland, Oregon, 2016	Gatziolis et al. (2016)
5	<i>Sphagnum girgensohnii</i>	SIRM, PM, 10 elements	Dubna, Russian Federation, 2015	Vukovic et al. (2015b)
6	<i>Orthotrichum lyellii</i>	Cd	Portland, Oregon, 2016	Donovan et al. (2016b)
7	<i>Sphagnum girgensohnii</i> moss bag	NOX, NO, NO ₂ , O ₃ , CO, BNZ and PM ₁₀	Belgrade, Serbia, 2016	Lazic et al. (2016)
8	<i>Sphagnum girgensohnii</i> moss bag	PAHs and Al, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr and Zn	Belgrade, Serbia, 2013	Vukovic et al. (2014)
9	<i>Sphagnum girgensohnii</i>	Pb	Belgrade, Serbia, 2011	Deljanin et al. (2013)
10	<i>Sphagnum girgensohnii</i>	Major and Trace metals	Belgrade and Moscow urban Area, 2011	Goryainova et al. (2016)
11	<i>Sphagnum girgensohnii</i> and <i>Hypnum cupressiforme</i>	Heavy metals and PAHs	Belgrade, Serbia, 2013	Vukovic et al. (2015c)
12	<i>Pterobryopsis flexiceps</i> , <i>Pinatellaalopccuroides</i>	Trace elements	Mumbai, India, 2004	Chakraborty et al. (2004)
13	<i>Fabrionia ciliaris</i> , <i>Leskea angustata</i>	Zn, Pb, Cr, and Cd	Toluca Valley, Mexico, 2011	Macedo-Miranda et al. (2016)
14	<i>Haplocladium angustifolium</i>	Ag, As, Cd, Co, Cr, Cu, Mn, Mo, Ni, V, Pb, and Zn	Wuhan City, China	Jiang et al. (2018)
15	The terrestrial moss samples	Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Rb, Sr, V, and Zn	Republic of Macedonia	Stafilov et al. (2018)

16	Hypnum cupressiforme and Pseudoscleropodium purum	Toxic trace metals (Cd, Cr, Co, Cu, Hg, Ni, Pb, and Zn) and metalloids (As)	Albania	Allajberu et al. (2017)
17	Network of Samples (31 moss samples)	Ag, Al, As, Au, Ba, Be, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hg, Ho, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, Sb, Sm, Sr, Tb, Th, Ti, U, V, Yb, Zn, Zr	Kavadarci, Republic of Macedonia	Bačeva et al. (2012)
18	Hypnum cupressiforme Hedw moss bags	14 trace elements	Southwestern part of Sardinia island, Italy	De Agostini et al. (2020)
19	Grimmia dissimulate bag	Heavy metals (Cr, Cu, Pb, Zn)	Harare, Zimbabwe	Gaza and Kugara, (2018)

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MICROPLASTIC POLLUTION: SOURCES, FATE, IMPACTS AND RESEARCH GAPS

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Abstract: The occurrence of microplastics into the ecosystem has become an eminent threat for the environment as well as gets extensive attention in recent times. Microplastic existence has severely affected lakes, rivers, oceans, coastal zones, and even polar zones biome. Microplastics (primary microplastics) mostly come from used products and by shattering of larger fragments. Through runoff, the microplastic enters into either aquatic or terrestrial environment where it can cause the devastating impacts not only to that ecosystem but also to the humans. Several studies professed that microplastics have a significant impact on marine and terrestrial communities. Microplastic particles are widespread in India, Asia, Southeast Asia, North America, Africa, South Africa, and Europe. The microplastic source and global distribution in the ecosystem, their effects on marine organisms, particularly in the food chain are illustrated in this review. Finding the principal sources of microplastic into the environment and raising the awareness among communities can significantly reduce the extent of microplastics pollution in the environment. This review article is an effort to create understanding about the microplastics pollution, sources and effects on environment. All the possible environmental friendly remediation strategies like bioremediation are also discussed in this article.

Keywords: Aquatic Biodiversity Impacts, Microplastic occurrence and distribution, Environment deterioration.

INTRODUCTION

Plastic refers to brittle and flexible entity which is mostly a synthetic substance that can be molded into various shapes. Plastic is a cheap, durable, lightweight, resilient, and non-corrosive substance with a high thermal and insulating capacity (Garcia and Robertson, 2017). The plastics consist of long-chain porous materials which comprise organic and inorganic ingredients like the carbon, hydrogen, silicon, and chlorine. These ingredients usually come from petroleum products such as coal or natural gas (Doghri et al., 2016). The most used artificial plastics are polyvinyl chloride (PVC), polypropylene (PP), polyethylene (PE), polystyrene (PS), and polyethylene terephthalate (PET) in nature that may have low or high densities (Ilyas et al., 2018). Synthetic plastics contribute up to 90% in total global plastics production. And it is believed that microplastic pollution is largely due to synthetic plastics in the environment (Adam et al., 2020). Microplastics is a term used to denote the smaller (generally micro sized) plastic residues found in aquatic and terrestrial environments. These microplastics are broken down into smaller sizes due to external environmental factors like high temperatures, ultraviolet rays and physical disintegration (Cox et al., 2019).

In 1972, E. J. Carpenter and K. L. Smith were the first investigators to draw attention to plastic particles found in North Atlantic surface (Amy Lusher, 2015). Scientists are in beliefs that the increase in plastic production combined with current disposal practices may lead to higher intensities on the ocean surface (Pauna et al., 2019). Currently, only known about biological role for those particles is because they behave as hydrates, diatoms, and even bacteria grow on the surface. Not surprisingly, just a few months later, fish ingested the same PE particles (Karbalaei et al., 2019). One of the predictions is at the center of

the scientific community, and they analyze the smallest plastic fragments as pollutants. Millions of tons of plastic have been delivered from the time of the middle of the past century (over 200 million tons per year) (Solomon and Palanisami, 2016). It was speculated that this plastic will eventually decompose and break in the ocean. Tiny plastic fragments (<5 mm) are scattered in the environment and migrate and collect in polar regions as well as in natural habitats from the sea surface to the seafloor. These fragments are also dumped on urban coasts and primitive sediments (Urban-Malinga et al., 2020). The plastic pollution is abundant and persistent throughout the world's seas and explicitly warns marine biological communities. In this review, we summarize the fate, source, and effects of microplastic pollution on the aquatic environment. To get a better understanding the interaction of microplastics with the natural environment, the important research gaps that need to be filled are also discussed.

SOURCES OF MICROPLASTICS

The resources of microplastics are mostly divided into primary and secondary microplastics (Boucher and Friot, 2017). The microplastics are produced for various purposes, including cosmetic abrasives, pharmaceutical carriers, and industrial and technical applications (**Figure 1**). Mostly, it is very difficult to remove microplastic using wastewater treatment technologies (Sun et al., 2019). Once in the wastewater, they eventually can become the part of the environment. Secondary microplastics come from larger plastics and gradually break down into smaller fragments under various complicated environmental conditions (like that temperature, wind, waves, and ultraviolet rays). By frequently uses of plastic products may lead to fragmentation and produced secondary microplastics (Barlow et al., 2020).

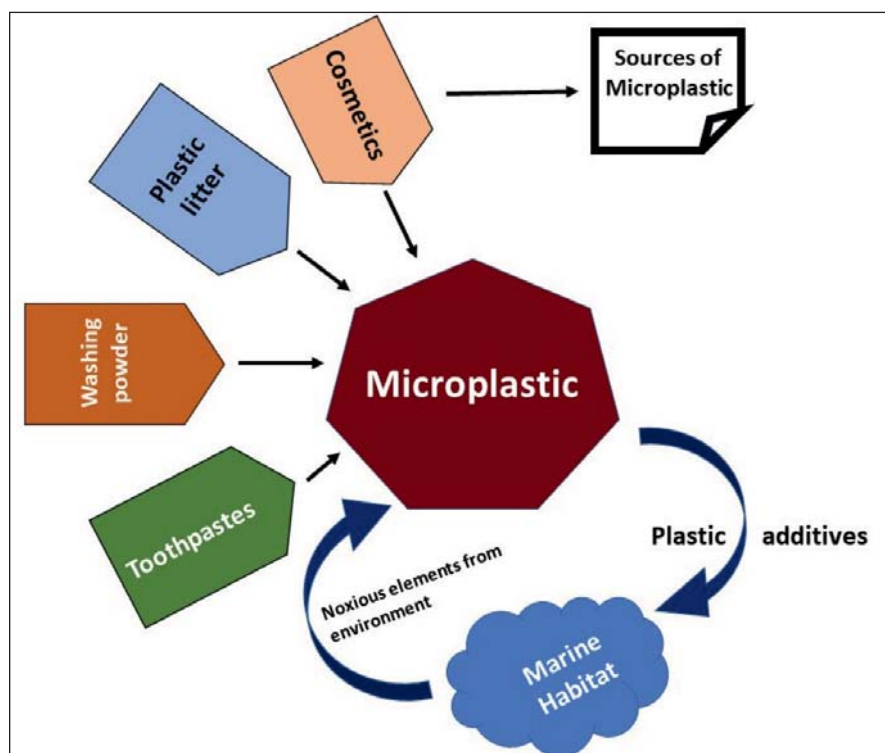


Figure 1: Sources of microplastics in environment

Scientists have found that the microfiber quality of the heaviest household machine in traditional clothing is 1,471 - 2,121 microfibers per garment, which is seven times that of the front-loading machine (Belzagui et al., 2019). A recent study found that 30,000 to 465,000 microfibers (or 175 to 560 microfibers/g)

is being disposed-off per square meter of textiles and clothing (Xu et al., 2018). However, plastic emissions linked to vehicle transportation, comprising tire wear, brakes, and road motifs, are other important sources in the ecosystem. It is estimated that global emissions of microplastics from tire wear on-road vehicles are 0.81 kg/year per capita (Kole et al., 2017). Except for road traffic, aircraft tire wear accounts for around 2% of total tire emissions in the Netherlands. Similarly, synthetic surface also plays an important part in the secondary source of microplastics. According to rough estimates, the annual emissions of artificial turf are between 760 and 4500 tons. Therefore, different kinds of microplastics are released into different environments and ecosystems (Rezania et al., 2018).

It is quite evident that microplastic distribution may involve the primarily land resources (80%), coastal tourism, leisure, commercial fishing (such as plastic fishing equipment 18%), seagoing vessels, and marine industries (Avio et al., 2017). Microplastics enter the soil from various sources, comprising landfills, soil changes, land use from sewage sludge, and sewage irrigation, Manure and organic material, agricultural mulch film residues, tire wear and atmospheric sediments. Plastic waste comprises all processes of soil biological activities, digestive and excretory processes and is broken down into microplastics (He et al., 2018). Microplastics existence diminishes soil quality, especially the relocation and nutrient movement of microplastics throughout heavily polluted soils.

PRIMARY MICROPLASTICS

Primary microplastics are specified as microscopic plastic fragments based on size. According to the chemical composition of microplastics, these are coming from the accidental release of plastic residue (such as particles, nodules, or mermaid cracks), biodegradable plastic products and are in the form of by-products such as the release of raw materials, dust and fibers (Guo et al., 2019)(Kershaw, 2015 #224;Kershaw, 2015 #224). Plastic pellets are raw materials that are used to produce the microspheres in plastic products (from pellets to plastic bags). Plastic particles are made up of lipophilic polystyrene (PS), polypropylene (PP), polyolefin and polyethylene (PE) particles, which means that they can easily absorb harmful and toxic chemicals in surface seawater. These synthetic microplastic substrates are also used as abrasive materials in numerous industries (cosmetics, detergents, pharmaceuticals, and blow molding media) (Hernandez et al., 2017). Various hydrophobic and aromatic hydrocarbons have also been detected in both aquatic and terrestrial ecosystems, like that dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCB) and polycyclic aromatic hydrocarbons (PAH) which bind on the surface of particles (Lohmann et al., 2017). Industrial resin pellets (2 – 5 mm) have been reported to be widely used on the coastlines of New Zealand, Lebanon, Canada, Bermuda, and Spain. The density of particles per meter of the beach usually exceeds 1,000 particles (Clunies-Ross et al., 2016).

According to the report, the PCB content in polypropylene fragments from Japanese beaches is very high. Descriptions of the presence of resin particles on coastlines in Singapore, India and Belgium indicate a prevalent distribution of tiny microplastic. These microplastics are used not just in facial scrub cleansers, hand sanitizers, and cosmetics, but also in drilling fluids and industrial abrasives for oil and gas exploration. To remove rust and paint, polyester microplastic washers with a particle size of 0.25 – 1.7 mm are utilized (Burrows et al., 2020). In cosmetics, the main components of pressed powders and skin cleansers are PE and PP particles (< 5 mm), PS balls (< 2 mm), and polyolefin particles (74 – 420 µm). In the analysis of skin cleaners, rough spherical particles made of PE and PS, blue or white linear and irregularly shaped particles can be used to identify. Microplastics can also be utilized as a drug shipment system (carrier) and tooth gloss for dentists. As a source for personal care, cosmetics, and medicines, the final plastic particles can insert in the marine environment through sewage (Sun et al., 2019). More detailed research work is also

needed to identify the basic sources and how to limit it in the environment. Moreover, research should be carried out to find a replacement for of the plastics for sustainable environmental purposes.

SECONDARY MICROPLASTICS

Secondary plastics are large size and high-density plastic fragments in terrestrial and marine habitats (Weinstein et al., 2016). Weathering causes large plastics to break down into smaller pieces. Another significant process is the photodegradation resulting from the ultraviolet radiation in sunlight, that is causing the breakdown of chemical bonds in the oxidation procedure. Besides the sources, there are 5 types of microplastics i.e. fibers, microbeads, fragments, nurdles and foams (Fischer and Scholz-Böttcher, 2017) (Fig. 2.)



Figure 2: Types and distribution of secondary microplastics and their commercial use

NANOPLASTICS

Nanoplastics are the smallest fragments of plastic less than 100 nm dimensions. (add reference here) The crushing or weathering of plastic waste creates micro and nano-plastics. When synthetic fibers break and plastic objects break down during the washing process (e.g. extended PS with a fast-track mechanical wear system), transfer into nano-plastics. Due to the decrease in the size of these nano-plastics with high surface area, various marine biota (like that corals, phytoplankton, and zooplankton) can ingest them easily. In addition to the microplastics itself, organic pollutants adsorbed/ absorbed on their surfaces adds to the potential harmful effects to aquatic life as well as humans (Ng et al., 2018).

ENVIRONMENTAL FATE OF MICROPLASTICS

The resources of waste of microplastics and microspheres (less than 2mm in size) on land account for 80% of all plastic waste in marine ecosystems. Households, industry and beach activities are the main route for plastic waste to enter the environment. The manufacture of plastic products from industrial residual materials, the burst of microscopic plastic particles and resin powder, tourism at coastal zone, fishing and aquaculture are other entails of microplastic contamination. These activities severely pollute the marine

environment and plastics residue enter water corpses via rivers, sewage and wind currents. In connection with this, the trash produced onboard by careless handling of plastic fishing gear (Lehner et al., 2019).

The polymer microplastics and nano-plastics sources in marine habitats include cosmetics, toothpaste, hand sanitizers, and various cleaning products by waterways as domestic wastewater through municipal and industrial sewage systems (Fu et al., 2018). In contrast to macromolecular plastics, microplastics and nano-plastics are not collected in a sewage treatment plant but are transported to the sea via river water together with wastewater and landfill leachate. The movement of microplastic waste from land to water is also controlled by natural procedures such as floods, winds and hurricanes (Braga Moruzzi et al., 2020). During the drying process and applying as agricultural fertilizer, micro powders and microspheres are released into the atmosphere through the decomposition of the agricultural PE film and sewage sludge. Besides, the advent of 3D printing technology for rapid prototyping, the supply of nanoparticles and nano-capsules polymer and the use of thermal cutting of PS foam to release nano-plastics (~20 – 220 nm) and ultrafine materials to release Polymer particles (11.5 – 116 nm) (Rodríguez-Hernández et al., 2020).

EFFECTS OF MICROPLASTICS

INTERACTION WITH MARINE BIOTA

When microplastic content rises then the bioavailability of pollutants for marine biota also increases. The color, aggregation, density, shape, and size of tiny particles have an impact on their potential bioavailability for marine biota. The biological interaction between microplastics and marine biota is crucial to comprehend the movement, influence and fate of microplastics into the marine ecosystem. Since the existing research has been undertaken within the controlled lab experiments, increasing the need of studies in practical environments on the absorption of microplastic fragments by marine biota and their effects. The uptake of microbial particles in numerous marine organisms has been observed worldwide (Ferreira et al., 2019).

In most cases, the absorption of microplastics by marine organisms is random as these particles are ingested mistakenly as food (Ferreira et al., 2019). The absorption of microplastics by marine biota has been studied, and most of the research comes from the analysis of gastric contents. When marine biota ingests microplastics, it can cause disorders in organelles to organismic levels. The microplastics consumed by marine biota can causes adverse health effects (Peng et al., 2020). The outer surface of the adhesive polymer is obstructed, which hampers the fluidity and blockage of the digestive system, or this effect can be a chemical reaction, like that inflammation, liver pressure and growth reduction (Zhang et al., 2018).

The consumption of microplastics by various non-nutritious marine organisms, containing invertebrates, particularly noctuid, mussels, sea cucumbers, amphibians and zooplankton as well as fish-eating birds, fish, turtles and animals, as microplastics ingested by nutrient-poor organisms (including zooplankton and foot-shell animals) can disrupt the food chain. Microplastics also contain organic toxins that are added in them during the manufacturing of plastics.. Depending on the larger specific surface area and the van der Waals force, chemical adsorbing is chiefly since organic toxins have a higher similarity for the hydrophobic surface of microplastics than seawater (Toussaint et al., 2019).

Due to the bulky volume ratio make the microplastics more vulnerable to water-based pollutants (like that persistent organic pollutant (POPs), toxic heavy metals, and endocrine-disrupting chemicals for years. These substances are present in high content in the microlayers on the ocean surface, and low-density

microplastics are also common in the microlayers on the ocean floor. Dichlorodiphenyltrichloroethane (DDT), polycyclic aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB), as well as other organochlorine pesticides, can be adsorbed on the hydrophobic surface of microplastics. The adsorption capability of microplastics is stimulated by the nature of the polymer and its conditions (glass or rubber). A large number of studies have shown evidence of traces of plastic pollution. Some scientists enumerated that the worldwide content of POPs in marine plastic particles is 1 – 10,000 $\mu\text{g g}^{-1}$. Marine biota has been used to metabolize POPs that have been adsorbed in microplastics (Ferreira et al., 2019).

For example, suggested that *Allorchestes compressa* absorbed Polybrominated Diphenyl Ethers (PBDE) from microplastics. It was found that the organism had taken in about 45 particles that were absorbed into the tissue. Scientists also suggested that fish absorb PBDE into tissues. Aquatic sediments can also sink into the aquatic environment as potential metals and be absorbed by microplastics. The main source of heavy metals is antifouling coatings, industrial waste, and fuel combustion to entering the marine ecosystem. Research has been enumerated the capability of microplastics to adsorb trace metals from a marine ecosystem. Heavy metals such as aluminum (Al), copper (Cu), silver (Ag), zinc (Zn), lead (Pb), iron (Fe) and manganese (Mn) have been detected in plastic product particles extracted from seawater (Singh et al., 2019). Microplastics covered by POPs and heavy metals can migrate through the ocean and certainly pollute further.

Also, the substance can be absorbed by marine organisms that are transported along with the food chain. Similarly, investigated the leaching of Zn and Cu from the antifouling coating of polyvinyl chloride fragments and pure PS spheres in seawater and adsorbed by microplastics. These harmful chemical pollutants have a variety of harmful effects, e.g. cancer and endocrine disorders, birth defects, immune system troubles and developmental problems in children. Plastics can also contain harmful additives that can get into the environment. These plastics have been shown the potential to migrate into the aquatic food chain and damage the marine biota that consumes them (Amereh et al., 2019).

The absorption of trace plastics in organic substances can take place through a ventilation process. In other words, as water flows through the bottom of the organism's limbs, small particles are absorbed into the cavity. Studies by (Ferreira et al., 2019) on the absorption of microplastics in the ocean explain its toxic effects, in particular the toxic effects on *pomatoschistus* microorganisms, zebrafish (*Danio rerio*), whales, microalgae, frivolous fish, flounder and pelagic fish (mackerel and herring).

MICROPLASTICS IN FISH

Research has shown that fish tissues contain the same chemical substances as plastic. The interaction between carnivores and prey increases the concentration of toxic chemicals from multiple resources accumulate into the body. With people concerned about the transmission of trace and detrimental chemicals between nutrient levels, and the impact on marine biota demonstrate by the laboratory studies of plastics. Several experiments have been conducted to evidence for microplastics carriage a threat to fish as ingesting microplastics before they ripen can cause death. Scientists explored the transmission and potentially harmful microplastic between different nutrient contents in the marine ecosystem. In research, *Artemia* sp. Nauplius was exposed to high concentrations of microplastic materials ($1.2 \times 10^6 \text{ mg}^{-2}$), although some accumulated microplastic particles are excreted from the body, but some remained in the epithelial cells and intestinal villi (Bessa et al., 2018). The study also found that the microparticles act as carriers for the transfer of the related persistent organic pollutant benzo (BaP) from nauplii to zebrafish, and the substance remained in the intestine where it was found in nauplii and zebrafish with no bodily harm was detected. Scientists showed that microplastics and related harmful materials can be carried

along the food chain at various nutrient levels. Scientists examined the adsorption of microplastics in marine fish and the effects of toxic chemicals (*Oryzias latipes*). Ingestion and accumulation of harmful chemicals can cause oxidative stress and hepatitis. There are other studies on the different fish intake of microplastic feed, about 18% in the central Mediterranean area. Of the top predators found micro, meso-sized swordfish (*Xiphias gladius*), bluefin tuna and tuna large plastic fragments of 65 mm or 5 – 25 mm and 25 mm (Romeo et al., 2015).

Scientists are recommending that 36.5% of microplastics be found in the gastrointestinal tract of pelagic and lower fish. The frequency of plastic particles per fish is between 1 and 15 pieces. Total 351 number of plastic particles were discovered with an fourier transform infrared spectroscopy (FTIR) (Gigault et al., 2016). There have been reports that 63.5% of benthic fish and pelagic fish contained trace plastic 36.5%. A total of 73 microplastics were found in the stomach of the fish. In another study on the absorption and effect of zebrafish on microplastics, it was found that most plastic particles (5 μm in diameter) aggregate in the intestines and liver, while plastic particles with a diameter of 20 μm only occur in diseases part of the intestine and liver (Karami et al., 2017). Therefore, the build-up of plastic particles can cause inflammation and lipid build-up in fish liver. It has also been noticed that microplastics can induce oxidative stress and alter the metabolic profile of fish liver, thereby disrupting lipid and energy metabolism (Yin et al., 2019).

In an experiment to examine the transfer of microplastic, which are absorbed by personal hygiene products. The rainbow fish (*Melanotaenia fluviatilis*) was exposed to microspheres that had adsorbed PBDEs monitored after 0, 21, 42 and 63 days. After ingestion, it was found that the exposed fish accumulate high amounts of PBDEs (approximately $115 \text{ pg g}^{-1} \text{ ww d}^{-1}$) in their tissues. According to reports, the Baltic Sea is severely polluted by the high content of microplastics ($7000 - 10,000 \text{ particles m}^{-3}$) (Wardrop et al., 2016). European sea bass (*Perca fluviatilis*) touches and absorbs 90 μm PS microplastic particles. This PS microplastic is absorbed and accumulated, resulting in decreased growth, impaired hatching, eating and behavior changes, and even impairment of the sense of smell, increasing the susceptibility to being killed by predators. This enables us to understand that the effects of microplastic ingestion go further than the direct effects on the digestive tract of fish (Karbalaie et al., 2019).

Studies show that fish prefer to eat pellets rather than natural foods. The inclination of PS microplastic particles for natural foods can be recognized to the size and shape of PS microplastics, which may make them suitable for ingestion, as described by Jovanović et al. (2018). Similarly, the color of PS microplastic particles can cause them to be ingested, as color is one of the properties of microplastics to attract prey. The number of habitats in Europe has declined sharply, and the research attributed this to the high contamination of the ocean by highly plastics materials.

MICROPLASTICS IN OTHER MARINE BIOTAS

The problem of trace collection is not limited to fish. Zooplankton and sea turtles are also vulnerable to microplastics. Performing outdoor mesoscopic studies to study the effects of plastics on the health and biological functions of edible *Ostrea edulis* and the structure of related large animals. The organism was exposed to low and high doses ($0.8 \mu\text{g}^{-1}$ and $80 \mu\text{g}^{-1}$) biodegradable and conventional microplastic treatment for 60 days. After exposure, the respiratory rate of edible oysters was observed to increase in response to high doses of polylactic acid (PLA) microplastics, indicating that the oysters were in a state of stress. Similarly, the wealth and biomass of related benthic organisms including periwinkles (*Littorina sp.*), Isopods (*Idotea balthica*) and chilli clams (*Scrobicularia Plana*) have also decreased. The decrease is due to microbial uptake and the resulting decrease in reproductive production and mortality as well as decreased food intake (Li et al., 2018).

Steer et al. (2017) examined the microplastic feeding of two ecologically significant zooplanktons in the North Pacific food web. The acid digestion method was used to assess zooplankton in small foot fish (*Neocalanus cristatus*) and mesophytic larvae (*Euphasia pacifica*). In the score pick up 1 particle in 34 plastic dishes and 1 particle in 17 eukaryotic animals. Among these, the absorption of microplastic particles in the symbiotic mercury glass is highest ($816 \pm 108 \mu\text{m}$), higher than Copod ($556 \pm 149 \mu\text{m}$). The results suggest that low levels of organisms in the marine food web absorb microplastic particles that may be caused by accidental or intentional ingestion of microplastics by biota, as microplastic particles may be confused with food. An example is salmon on the northwest coast or in North America, which are told to eat many ichthyro pods and cut the animals off.

Wesch et al. (2016) have proved the influence of PS microspheres on the feeding, function and fertility of the marine animal, *Calanus helgolandicus*. The peopods were exposed to 75 ml^{-1} PS beads and $250 \mu\text{g L}^{-1}$ algae. It was observed that human feet exposed to microplastics ingested fewer algal cells, resulting in an 11% reduction in algal cells and a significant reduction in carbon biomass (40%). Prolonged exposure can lead to the death of some pods, decreased egg production, and decreased reproductive performance, all of which affect hatching. Studies have shown that food feet exposed to microplastics use up energy over time, making it difficult for food feet to find food. The result has also shown that exposure to high levels of microplastics can affect the survival of zooplankton. Consumption of filter-feeding biota is a very significant part of the marine nutritional web and their deterioration in the water environment may be able to pose a grave threat to many nutritional levels (Sharma and Chatterjee, 2017).

Considering that many microplastic particles enter the aquatic atmosphere, the bioavailability of microplastics and detrimental organic contaminants (bisphenol A, PBDEs, DDT, etc.) sticks to the microplastics and is ultimately absorbed by aquatic animals and entered into the food chain. It is rich in marine life and therefore has high bioavailability. People are increasingly concerned that large quantities of toxic chemicals are causing infertility, genetic damage, poisoning, decreased food intake, and improved mortality of marine life and humans (Guzzetti et al., 2018).

MICROPLASTICS: A GROWING HUMAN HEALTH CONCERN

The increased consumption of plastics is leading to increased performance of microplastics in humans. Under conditions of high concentration or high individual sensitivity, microplastic inflammatory lesions may be the cause, resulting from their surface ability to interact with tissues. The increased incidence of neurodegenerative diseases, immune disorders, and cancer may be due to increased exposure to environmental pollution, including micro-pollution (Fig. 3). However, knowledge on the affects of environmental exposure to of microplastics on human health is limited, to high uncertainties that should not be translated into alarmism even when applying the precautionary principle. With the anticipated growth of these synthetic materials in our environment, more studies are needed to fully understand the risk of microplastics to human health, requiring knowledge on human exposure, pathogenesis, and effects (Carbery et al., 2018).

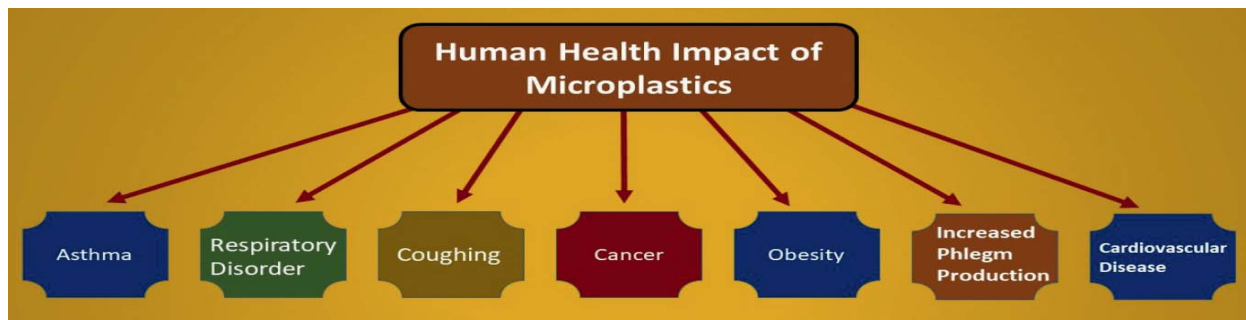


Figure 3: Health hazards of microplastics on human health.

REMOVAL/REMEDIATION OF MICROPLASTICS FROM ENVIRONMENT

Although different laboratory scale studies have reported effective remediation of microplastics in the environments; but when it comes to the practical applications, it lacks the efficient monitoring technology which monitors and records the remediation process.

Different technologies like membrane bioreactors, retrofiltration, and bioremediation using different microplastics degrading microbes are studied (Wagner and Lambert, 2018).

CONCLUSIONS AND FUTURE RESEARCH

Plastic contamination in the marine ecosystems is in a worrying situation as it is ubiquitous in the natural environment. It also has detrimental effects on aquatic biota and spreads along with the food web, which is a problem. There is an urgent need to take strong action at international, national and local levels to resolve this problem. Developing countries such as India, South Korea, Vietnam, Sri Lanka, Pakistan, Indonesia, China, Bangladesh, Thailand, and the Philippines mainly cause plastic pollution in the ocean and atmosphere (reference needed here). Microplastics are very tiny plastic particles that are entering the marine ecosystem from two major sources. Cosmetics are typically used when larger fragments of plastic are weathered into smaller ones. In general, this type of plastic enters the marine ecosystem through runoff from rivers, drainage systems, sewage treatment plants, and exposure to wind, water, and waves. Microplastics are dispersed in aquatic environment where they accumulate, disintegrated and converted to smaller in size (nanoplastics) and cause more damages to organisms. Microplastics are very common in the water column, surface water and sediments in Europe, Asia, Africa and North America. Due to its small size, microplastics they are readily absorbed by marine biota and accumulates in the tissues, circulatory system and brain.

The absorption of many marine biota and the presence of sea salt clearly show the degree to which the microplastics are harmful to the entire ecosystem. This is very worrying as microplastics can cause serious harm to marine life and humans. Since existing methods cannot be eliminated, these particles will inevitably continue to increase over the next few years. Without the participation of the public, socio-economic departments, tourism and firms that specialize in waste management impossible to reduce the problem of microplastics. Also, the bacteria can then be used to clean up contaminated environments. Using microorganisms to break down microplastics is a hopeful and eco-friendly action plan. It can protect the managing of microplastics from negative influences and ultimately help to naturally cleanse the polluted environment.

Many countries in the developing world have not invented laws and regulations to regulate and monitor the microplastic pollution.

- It is therefore suggested that local governments formulate strict laws and regulations and encourage examination to monitor the long-term environmental impact of plastic waste. For protection

management, new scientific data on contamination by microplastics should be devised, normative guidelines should be formulated and the basis for awareness-raising campaigns should be strengthened.

- Public awareness of microplastic pollution is very important as it determines their behavior when consuming plastic and, most crucially, the negative consequences of plastic pollution are not yet recognized by general population.
- Various campaigns and plans should be implemented that can play a significant role in raising public awareness of the long-period and long-term consequences of plastic contamination. Some maritime active international organizations such as the International Maritime Organization (IMO) and the United Nations Environment Program (UNEP) should organize particular campaigns at a global level to reduce microplastic contamination.
- Ultimately, the plastics industry should be responsible for and keep their scrap products. The government would set a “zero tolerance” on this subject, forcing the industry to utilize biodegradable substances like starch, lignin, cellulose rather than non-degradable materials. This biodegradable substance then broken down by microorganisms (bacteria/fungi) and eventually shortens the lifespan of the following are plastics in the environment.

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ESSENTIAL OILS AS GREEN REPELLENTS AGAINST MOSQUITO VECTORS

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Abstract: The mosquitoes are a serious threat to public health, since they are known vectors of many life-threatening diseases. Mosquito-borne diseases cause millions of deaths worldwide every year. While mosquitoes are important to maintain ecosystems, the aim is to keep them out of our personal space. People looking for alternatives to synthetic mosquito repellents may find that some natural repellents are effective in protecting them from bites. Natural insect repellents use natural ingredients such as essential oils and other plant-based elements. Certain essential oils are effective and helpful in repelling mosquitoes, and are a natural alternative to the harsh chemicals in commercial bug sprays. These products are also likely to be less toxic to humans and the environment. Natural repellents and some essential oils may be effective in keeping mosquitoes away because they block their sense of smell. Many natural scents that are appealing to humans actually repel mosquitoes. Plant - based repellents are becoming more widely used as a protecting measure against mosquito bites, but more research is needed to develop natural repellents in terms of improving their repellent efficiency as well as in terms of their safety for use. This article presents a review about the best essential oils used as green repellents against mosquito bites, their efficiency, development and testing.

Key words: mosquito - borne diseases, plant-based repellents, essential oils.

INTRODUCTION

Mosquitoes are carriers, or vectors, for some of humanity's most deadly illnesses, and they are public enemy number one in the fight against global infectious disease. As a result of global economic trends and climate change, there is the possibility of intensifying vector populations, thereby increasing the number of persons infected by vector-borne diseases.

Vectors such as mosquitoes and ticks are cold-blooded and are particularly sensitive to climate factors. Global climate changes cause a big problem with the spread of mosquitoes. It can be said that the mosquitoes benefit from changes in the climate. Global warming has allowed mosquitoes, ticks and other disease-bearing insects to proliferate, adapt to different seasons, migrate and spread to new areas that have become warmer, areas where earlier they have never been detected. This means that more humans are exposed to viral infections such as Malaria, Dengue fever, Zika, West Nile fever, Yellow fever, and many more.

Repellency is an important way of preventing vector - borne diseases by reducing man - vector contact. Most commercially available repellents are prepared by using chemicals like DEET (N,N-Diethyl-meta-toluamide), DMP (dimethyl phthalate) and allethrin. But, these chemical repellents are not safe for public use because of their potential toxicity, they cause negative impact on the environment, have high operational cost. Therefore it is needful to develop environmentally friendly, long - lasting, low cost and preferably locally available repelling agents for mosquito control. The biologically active materials derived from the plant sources have been reported either as insecticides for killing larvae or adult mosquitoes, or as repellents for mosquito biting (Lee, 2018). They are generally more biodegradable, less hazardous and are one of the best alternatives for mosquito control.

Essential oil has been the active component of most important herbal remedies since ancient times. Many natural scents that are appealing to humans actually repel mosquitoes, including lavender, pepper-

mint, basil and eucalyptus. Essential oils are volatile naturally occurring, complex compounds, mixtures of hydrocarbons with a diversity of functional groups, characterized by a strong odor and are formed by plants as secondary metabolites. The metabolites like the monoterpenes such as - pinene, cineole, eugenol, limonene, terpinolene, citronellol, citronellal, camphor and thymol are the common constituents in a number of essential oils having mosquito repellent activity. Essential oils extracted from different families have shown high repellency against arthropod species (Lee, 2018; Mayura and Siriporn (2015)).

ESSENTIAL OILS AS MOSQUITO REPELLENTS

LEMON EUCALYPTUS OIL

PMD (para-menthane-3,8 diol) is a major repellent ingredient extracted from the leaves of lemon eucalyptus. It also can be chemically synthesized for use in commercial repellents. Citronellol, limonen and linalool are active compounds found in the extracts from eucalyptus, together with PMD. Oil of lemon eucalyptus extract or PMD is a plant-based ingredient that has been proven to prevent mosquito bites. Many plant extracts and oils show mosquito repellent activity but their effect lasts very short, from several minutes to several hours because their active ingredients are highly volatile, and after application they rapidly evaporate leaving the user unprotected. Unlike these active ingredients, PMD is highly effective and long-acting mosquito repellent, similar to DEET, because it has a lower vapor pressure than volatile monoterpenes found in most plant oils (Barasa, Ndiege, Lwande and Hassanali, (2002)). Environmental Protection Agency (EPA) has registered the lemon eucalyptus oil or PMD as a biopesticide repellent derived from natural materials in 2000 (Lee, 2018). Due to its proven clinical efficiency to prevent malaria and having no risk to human health, PMD has been recommended, by Centers for Disease Control (CDC), as the only plant - based repellent, for use in disease endemic areas (Emily Zielinski-Gutierrez and Roger (2010); EPA). A researchers from Australia in their study in 2014 have found that a formula containing 32% lemon eucalyptus oil provided at least 95% protection from mosquitoes for 3 hours (Frances , Rigby and Chow (2014)). In other two studies, led by Rodriguez, comparing the effect of different formulations on repellency of disease-carrying mosquitoes *Aedes albopictus* and *Aedes aegypti* when applied to participants hands, researchers found that a plant-based spray that contains oil of lemon eucalyptus, was the only DEET-free formula to deliver strong and long-lasting results (Rodriguez, Drake, Price and Hammond (2015); Rodriguez et al. 2017). Two different laboratory studies have confirmed that 20% PMD applied topically can provide 100% protection from *A. Stephensi* for 11 -12 hours and 100% protection for 2 hours against *Ae. Aegypti* (Trongtokit, Curtis and Rongsriyam (2005); Fradin and Day (2002)). (Table 1).

Table 1. Mosquito repellent efficiency of lemon eucalyptus oil

Plant	Other names	Active ingredients	Application	Repellency protection [%]	Type of study	References
Myrtaceae						
Corymba citriodora	lemon eucalyptus	citronellal	20% PMD (1.7mg/cm ²) applied topically	100% prot. for 11-12 h against <i>A. stephensi</i>	Laboratory study	Trongtokit, Curtis and Rongsriyam (2005)
		PMD citronellol limonene geraniol isopulegol δ - pinene	20% PMD applied topically	100% prot. against <i>Ae. Aegypti</i> for 120 minutes	Laboratory study	Fradin and Day (2002)
			30% PMD applied topically	96.88% prot. for 4 hours	Field study in Bolivia	Moore, Lenglet, and Hill (2002)

CITRONELLA OIL

Citronella oil is obtained from the leaves and stems of different species of the tropical island plants from the grass family. Essential oils and extracts belonging to plants in the citronella genus are commonly used as ingredients of plant-based mosquito repellents. Today, citronella is one of the most widely used natural repellents on the market. The efficiency of citronella-based repellents to deter mosquito biting lasts very short, about two hours, but the formulation of the repellent is also very important (Trongtokit, Rongsriyam, Komalamisra and Apiwathnasorn (2005); Goodyer, et al. 2010). Initially, citronella, containing citronellal, citronellol, geraniol, citral, α pinene, and limonene, shows similar effectiveness as DEET, but the oil rapidly evaporate causing loss of efficiency and leaving the user unprotected. Citronella oil, only contains trace quantities of naturally occurring constituent PMD (para-menthane-3,8-diol), which is primarily responsible for the efficiency for repelling biting insects and other arthropods. Trongtokit and his coworkers have shown that the topical application of 100% citronella can provide complete protection against three mosquito species (*Ae. aegypti*, *C. quinquefasciatus* and *A. dirus*) for a particular time in a laboratory setting (Trongtokit et al. (2005). Another research team have tested the repellency protection of the citronella essential oil (*Cymbopogon winterianus*) against the same three mosquito species and the results are given in the Table 2.

Table 2. Mosquito repellent efficiency of citronella oil

Plant	Other names	Active ingredients	Application	Repellency protection [%]	Type of study	References
Poaceae						
<i>Cymbopogon</i> spp.						
<i>C. nardus</i>	citronella	citronellal	100% ess. oil applied topically	100% prot. against <i>Ae. aegypti</i> for 120 min., 100% prot. against <i>C. quinquefasciatus</i> for 100 min., 100% prot. against <i>An. dirus</i> for 70 min	laboratory study	(Trongtokit, Rongsriyam, Komalamisra and Apiwathnasorn (2005)
				100% prot. for 7-8h against <i>An. stephensi</i>	laboratory study	Tawatsin, Wratten, Scott, Thavara and Techadamrongsin (2001)
			40% ess. oil applied topically			
<i>C. winterianus</i>			100% ess. oil applied topically	100% prot. against <i>A. aegypti</i> for 3h, 100% prot. against <i>C. quinquefasciatus</i> for 8 h, 100% prot. against <i>An. dirus</i> for 3.5 h	laboratory study	Tawatsin, Wratten, Scott, Thavara and Techadamrongsin (2001)
<i>C. citratus</i>	lemongrass oil grass	citral α -pinene	100% ess. oil applied topically	74% prot. against <i>An. darlingi</i> for 2.5h and 95% prot. against <i>Mansonia</i> spp. for 2.5h	field study in Bolivia	Moore, Hill, Ruiz and Cameron (2007)

CLOVE OIL

Clove oil has been widely used in food, cosmetics and medicine and in insects repellents as well. Clove oil distilled from *Syzygium aromaticum*, was reported as the most effective mosquito repellent in the comparison with other essential oils made by some researchers. They showed that this oil gave 90 to 225

min of protection against *Ae. aegypti* and 75 to 213 min of protection against *An. albimanus* depending on oil concentration (Barnard, 1999). Another research team performing laboratory study proved that applying 100% clove oil topically can provide 100% protection for 120 min., 240 min., and 210 min., against *Ae. aegypti*, *C. quinquefasciatus* and *An. dirus*, respectively (Trongtokit et al. (2005)). The comparison of two different laboratory test results is given in the Table 3 and indicate that a topical solution of 100% clove oil could provide 100% efficiency at blocking some mosquitoes for between 120 and 225 minutes. The major constituents of clove oil are eugenol, eugenol- acetate and beta-caryophyllene. As far as safety is concerned, the same study found that clove's active ingredient, eugenol, could be safely used at around a 0.5% concentration. Higher concentrations may be generally safe also, but users risk skin irritation if they choose to use clove oil topically.

Table 3. Mosquito repellent efficiency of clove oil

Plant	Other names	Active ingredients	Application	Repellency protection [%]	Type of study	References
Myrtaceae						
Syzygium aromaticum	clove	eugenol	100% ess. oil applied topically	100% prot. against <i>Ae. aegypti</i> for 225 minutes	laboratory study	Barnard 1999
		eugenol acetate β-caryophyllene carvacrol thymol cinnamaldehyde	100% ess. oil applied topically	100% prot. against <i>An. albimanus</i> for 213 minutes	laboratory study	
				100% prot. against <i>Ae. aegypti</i> for 120 min. 100% prot. against <i>C. quinquefasciatus</i> for 240 min. 100% prot. against <i>An. dirus</i> for 210 min.		Trongtokit, Rong-sriyam, Komalamisra and Apiwathnasorn (2005)

PEPPERMINT OIL

Peppermint oil extracted by steam distillation from the leaves of *Mentha piperita* has a long tradition of medicinal use. It has high menthol content and also contains menthone and menthyl acetate. Menthone, present in high concentration in peppermint oil, is reported to act as a natural pesticide. Because of increased interest in developing plant origin insecticides as an alternative to chemical insecticide, the availability, low budget and less environmental impact, there are studies undertaken to assess the larvicidal and repellent potential of the essential oil of peppermint plant, *M. piperita* against larva of these three mosquito species (*Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*), and adult stages of these three species (*Anopheles annularis*, *Anopheles culicifacies* and *Culex quinquefasciatus*) (Ansari, Padma, Mamta and Razdan (2000)). The oil has shown strong repellent action against adult mosquitoes when applied on human skin. The results are given in the Table 4 and it shows that percent protection obtained against first specie is 100% for 11 hours, for second one it is 92.3% for 8 h, and for the last one the protection percentage is 84.5 for 8h. This study has shown that peppermint oil has also the larvicidal activity against different species of mosquitoes and can be used selectively in places where water is stagnant. Sarita and his colleagues found that peppermint essential oil was effective against mosquito larvae and provided 100% protection against bites from adult dengue fever mosquitoes (*Ae. aegypti*) for up to 150 minutes (Sarita, Naim and Radhika (2011)).

Table 4. Mosquito repellent efficiency of peppermint oil

Plant	Other names	Active ingredients	Application	Repellency protection [%]	Type of study	References
Lamiaceae						
Mentha piperita	peppermint	menthol menthone menthyl acetate	100% ess. oil applied topically	100% prot. against <i>An. annularis</i> for 11 h 92.3% prot. against <i>An. culicifacies</i> for 8h 84.5% prot. against <i>C. quinquefasciatus</i> for 8 h	field study	Ansari, Padma, Mamta and Razdan (2000)
			application of 3ml/m ² of water surface	100% mortality for <i>C. quinquefasciatus</i> within 24h 90% mortality for <i>Ae. aegypti</i> within 24h 85% mortality for <i>An. stephensi</i> within 24h	laboratory study	
			100% ess.oil applied topically	100% prot. against <i>Ae. aegypti</i> for 150 min.	field study	
			100% ess.oil applied topically	100% prot. against <i>Ae. aegypti</i> for 45 min.	laboratory study	Sarita, Naim and Radhika (2011) Barnard 1999

IMMORTELE OIL

Immortelle essential oil is distilled from the flowering tops of the plant *Helichrysum italicum*. This essential oil is effective as wound healing agent and for healing several skin disorders. There are several studies that have investigated the larvicidal potential of immortelle oil against some mosquito species. Laboratory bioassays on insecticidal activity of essential oils extracted from six Mediterranean plants have been carried out against the larvae of the mosquito *Aedes albopictus* by Barbara Conti and the colleagues (Conti, Canale, Bertoli, Gozzini and Pistelli (2010)). They have also investigated the chemical composition of the six essential oils. It was proved that different mortality responses are a function of both oil type and dosage rate. The results from this study has shown that immortelle oil from *H. italicum* has significant amounts of oxygenated monoterpenes and the highest level of sesquiterpenes (Neril acetate, α - Pinene, Limonene, γ -Curcumene, Neril propionate and Nerol). At the highest dosage of 300 ppm, immortelle oil from *H. italicum*, has showed a higher mortality than the other oils, with 100% mortality rate (Table 5).

Table 5. Mosquito repellent efficiency of immortelle oil

Plant	Other names	Active ingredients	Application	Repellency protection [%]	Type of study	References
Asteraceae						
Helichrysum italicum	immortelle	neryl acetate α -pinene limonene γ -curcumene neril propionate nerol	dosage rate of 200 ppm	41.7% mortality for <i>Ae. albopictus</i> within 24h	laboratory study	Conti, Canale, Bertoli, Gozzini and Pistelli (2010)
			dosage rate of 250 ppm	81.7% mortality for <i>Ae. albopictus</i> within 24h		
			dosage rate of 300 ppm	100% mortality for <i>Ae. albopictus</i> within 24h		

LEMONGRASS OIL

Lemongrass, scientifically known as *Cymbopogon citratus* is an herb with a subtle citrus flavor. One study found that topical application of lemongrass essential oil provided 74–95% protection for 2.5 hours against two types of mosquito during a field study (Moore, Hill, Ruiz and Cameron (2007)). Mayura and Siriporn investigated the repellent efficiency of mixtures of different essential oils and showed that a combination of lemongrass essential oil and olive oil provided 98.8% protection and the combination of lemongrass and coconut oils showed 98.9 % protection against the two species of mosquito (*Ae. aegypti* and *C. quinquefasciatus*) (Mayura and Siriporn (2015)). The results of these research works are given in Table 6.

Table 6. Mosquito repellent efficiency of lemongrass oil

Plant	Other names	Active ingredients	Application	Repellency protection [%]	Type of study	References
Poaceae						
<i>Cymbopogon citratus</i>	lemongrass	citral α -pinene	topically	74% prot. against <i>An. darlingi</i> for 2.5h	field study in Bolivia	Moore, Hill, Ruiz and Cameron (2007)
				95% prot. against <i>Mansonia</i> spp. for 2.5 hours		
			topically lemongrass oil + olive oil	98.8% prot. against <i>Ae. aegypti</i> for 60 min.	laboratory study	Mayura and Siriporn (2015)
			topically lemongrass oil + coconut oil	98.9% prot. against <i>Ae. aegypti</i> for 85 min.		
				and <i>C. quinquefasciatus</i> for 170 min		
				and <i>C. quinquefasciatus</i> for 115 min		

BASIL OIL

Basil (*Ocimum basilicum*) is a common ingredient in many cuisines, but it may also be a moderately effective mosquito repellent. There are several studies testing basil as a repellent. Some field studies in Kenya found that just the potted plant can provide nearly 40% protection against a type of mosquito that can carry malaria (*An. gambiae*) (Seyoum, Kabiru, Lwande, Killeen, Hassanali and Knols (2002); Seyoum, Killeen, Kabiru, Knols and Hassanali (2003)). The study of Adam and the associates aimed to evaluate the repellent activity of essential oil extracted from *O. basilicum* and to formulate cream repellent for mosquitoes from this essential oil (Almardi, Salma, Thana, Rasha, Salma and Omer (2019)). Major compounds in the investigated basil oil were linalool, cinnamic acid and eucalyptol. In this work, the oil was assessed for topical repellence effects against malarial vector *Anopheles* mosquito in cages. The essential oil was tested at three different concentrations 2, 4 and 6% of the oil. From the results obtained, the essential oil of *Ocimum basilicum* exhibited relatively high repellency effect (> 250 minutes at 6% concentration). Tawatsin and others in their work have investigated the repellent efficiency of the basil oil of *Ocimum americanum* (Tawatsin, Wratten, Scott, Thavara and Techadamrongsin (2001)). They have found that this essential oil provides 100% efficiency for 3h, 3.5h and 8h against *Ae. aegypti*, *A. dirus* and *C. quinquefasciatus*, respectively (Table 7).

Table 7. Mosquito repellent efficiency of basil oil

Plant	Other names	Active ingredients	Application	Repellency protection [%]	Type of study	References
Lamiaceae						
<i>Ocimum americanum</i>	basil	p-cymene	potted plant	39.7% protection against <i>An. gambiae</i>	semi-field study in Kenya	Seyoum, Kabiru, Lwande, Killeen, Hassanali and Knols (2002)
		estragosol				
		linalool	potted plant	37.9% protection against <i>An. gambiae</i>	field study in Kenya	Seyoum, Killeen, Kabiru, Knols and Hassanali (2003)
		linoleic acid				
<i>Ocimum basilicum</i>	basil	eucalyptol	100% ess. oil applied topically	100% prot. against <i>A. aegypti</i> for 3h, 100% prot. against <i>C. quinquefasciatus</i> for 8 h, 100% prot. against <i>An. dirus</i> for 3.5 h	laboratory study	Tawatsin, Wratten, Scott, Thavara and Techadamrongsin (2001)
		eugenol				
		camphor				
		citral				
		thujone				
		limonene				
<i>Ocimum basilicum</i>	basil	ocimene				
		linalool	2% ess. oil applied topically	125 min. prot. against <i>Anopheles</i>	laboratory study	Almardi, Salma, Thana, Rasha, Salma and Omer (2019)
		cinnamic acid	4% ess.oil applied topically	200 min. prot. against <i>Anopheles</i>		
		eucalyptol	6% ess. oil applied topically	270 min. prot. against <i>Anopheles</i>		
		α - citral				
		eugenol				

INCREASE IN EFFICIENCY OF ESSENTIAL OILS REPELLENTS

The application of plant-based repellents is increasing due to the fact that consumers want to protect themselves from mosquito bites but at the same time to use products that do not have a detrimental effect on them and on the environment. Considering that essential oils are highly volatile, evaporate quickly and leave the user unprotected, the biggest challenge in applying essential oil-derived repellents is to increase their effectiveness and extending their longevity. Aiming to that, many researchers work to develop methods that will make this possible.

SYNERGISTIC INTERACTION

Combination of several essential oils from different plants which lead to synergistic effect, is one of the most used methods for improvement of the repellent efficiency. The synergistic interaction of a mixture of active compounds from different essential oils provides a higher effectiveness of the repellents, compared to the sum of the efficiencies that each component has individually. Das and his associates have investigated the synergistic mosquito-repellent activity of *Curcuma longa*, *Pogostemon heyneanus* and *Zanthoxylum limonella* essential oils (Das, Dhiman, Talukdar, Rabha, Goswami and Veer (2015)). Their work shows that at an optimum concentration of 20%, the essential oils of *C. longa*, *Z. limonella* and *P. heyneanus* provided complete protection time of 96.2, 91.4 and 123.4 min, respectively, against *Aedes albopictus* mosquitoes in the laboratory. The 1:1:2 mixture of the essential oils provided 329.4 and 391.0 min of CPT in the laboratory and field trials, respectively. Another research group has evaluated synergistic effect of different combinations of ten essential oils against *Aedes aegypti*. In the study of protection period, litsea

+ rosewood in the ratio of 1:1 (v/v) at 10% concentration showed 86% repellency for 4 hours against this vector of dengue and chikungunya (Uniyal et al. 2015). Three most toxic essential oils (Manuka, oregano, and clove bud essential oils) were examined for their chemical composition and combined toxicity against *Ae. aegypti* larvae. This results revealed a synergistic interaction between Manuka and oregano essential oils and an antagonistic interaction between Manuka and clove bud essential oils (Muturi, Ramirez, Doll and Bowman (2017)). Other study was designed to compare the behavioral responses of *Aedes aegypti* to a single essential oil and to a mixture of two or three essential oils. Mixtures were prepared from essential oils extracted from *Litsea cubeba* (LC), *Litsea salicifolia* (LS), and *Melaleuca leucadendron* (ML). Greater contact irritancy was seen from mixed oils of LC and LS than with other mixed oils. Mixtures of LC and LS at 0.075% showed the highest synergistic action (65.5% escaped) compared to that with unmixed oil alone at the same concentration (LC=20% and LS=32.2%). In addition, mixtures of LC and LS at 0.075% demonstrated the highest non-contact repellency (62.7%) and showed a greater effect than the use of LC (20%) or LS (20.3%) alone (Noosidum, Chareonviriyaphap and Chandrapatya (2014)).

FORMULATION TECHNOLOGY DEVELOPMENT

Essential oils derived from different plants show significant mosquito repellent activity. But as mentioned earlier, due to the high volatility of the active phase, the repellent effects rapidly diminish. The duration of protection time can be improved via formulation technology development, by retaining the active components on the skin for longer periods. Improving the effectiveness of the repellent can be achieved by applying cream-based formulations and polymer mixture-based formulations. Ointment and cream formulations of lemongrass oil in different classes of base and the oil in liquid paraffin solution have been evaluated for mosquito repellency in a topical application. Base properties of the lemongrass oil formulations influenced their effectiveness. The oil demonstrated efficacy from the different bases in the order of hydrophilic base > emulsion base > oleaginous base. This study showed that the mosquito bite-deterrent effect of 15%v/w hydrophilic ointment formulation of the oil is very promising for topical use (Oyedele, Gbolade, Sosan, Adewoyin, Soyelu and Orafidiya (2002)). Another study was conducted to determine the mosquito repellent activities of some selected plant materials in order to obtain safe and efficient herbal mosquito repellent formulations by combinations of the selected plant materials. It showed that plant essential oils showed higher mosquito repellent activities compared to plant extracts. In order to obtain the products with improved repellent efficiency, two herbal mosquito repellent formulations have been made, using highly volatile essential oils together with herbal extracts. The prepared mosquito repellent gel and the mosquito repellent spray which contained 16% (V/V%) total active ingredients each, showed 100% mosquito repellency for outdoor and indoor field trials which were carried out for six hours each day for two days (Ranasinghe, Arambewela and Samarasinghe (2016)). Citronella essential oil has been reported as an excellent mosquito repellent, but because of the irritant nature and rapid volatility, its topical application is limited. Yadav and others in their study reported a novel approach to develop a mosquito repellent cream formulation of citronella oil using phase inversion temperature technique and evaluating the cream by texture analyzer for firmness/hardness, spreadability, and extrudability. Safe and effective mosquito repellent cream formulation of CEO was successfully developed (Yadav et al. 2014).

MICROENCAPSULATION, FIXATIVE AGENTS, NANOTECHNOLOGY

Microencapsulation is another way to improve the efficiency of the essential oils repellency. It resulted with sustained release properties and long-lasting repellency of the encapsulated oil. A research work has shown that increased repellent efficacy was achieved by microencapsulation of thyme oil (Chung, Seo,

Lim, Park, Yea and Park (2013)). It is also not uncommon to use fixative agents to increase the effectiveness of essential oil based repellents. The most widely used fixative agents for this purpose are vanillin, salicylic acid and paraffin. Adding vanillin in citronella oil and *Zanthoxylum piperitum* oil has extended their protection time to 4.8h and 2.5 h, respectively (Chung et al. 2013). The development of nanotechnology has enabled it to be applied in the field of preparation of effective plant based repellents. The biosynthesis of silver nanoparticles using *Quisqualis indica* has given good results in improving efficiency against malaria and Zika virus mosquito vectors. (Govindarajan, Vijayan, Kadaikunnan, Alharbi and Benelli (2016)).

CONCLUSION

Due to the possible harmful effects on human health and the environment, synthetic repellents against arthropods, are increasingly being replaced by plant-based repellents. Studies in recent decades show that plant essential oils can be considered a viable alternative to synthetic repellents. Increasing the repellent efficiency as well as extending the duration of protection time of natural repellents are the main challenges in the technology of development of natural repellents. The progress in the field of biotechnology, nanotechnology and formulation technology can enable the development of essential oil-based repellents that have the aforementioned properties. This paper is intended to attract the attention of entomologists and people in the field of mosquito-borne diseases, to understand the potential use of essential oils as green repellents against mosquito vectors.

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ROLE OF SANITARY ENGINEERS IN PREVENTION OF COVID-19 PANDEMIC

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Abstract: Among the most emphasized consequences of pandemic COVID-19 influence is a negative trend of economic development and lock down of many production companies.

One of areas where sanitary engineers can be engaged is drinking water safety and safety of wastewater. The new situation requires the change of actual teaching content during the teaching process of sanitary engineers, with the purpose of their training for inclusion in activities on prevention of virus spreading and controlling subjects in charge of people health protection, food safety and protection of living environment.

It is very important that higher school institution authorities become familiar with knowledge gaps, potential implications on food, water and environment safety, research direction and other issues related to virus control, among which is also SARS–COV-2.

The aim of this work is to encourage wider discussion on promotion of the actual study programs on higher institutions in Bosnia and Herzegovina and neighbouring countries as well as development of content proposals, which can lead to knowledge promotion, and competence of graduated students.

During the recent discussion, we came to conclusion that it is necessary to develop studies, which have multidisciplinary approach, including the area of public health system, quality, food safety, environment protection and administrative law.

Apart from that, students should obtain the necessary knowledge level in area of organization, management and economy, and with the purpose of enabling continuous production and income creation. We should also develop student research capabilities.

Key words: sanitary engineering, Covid-19, food safety.

JEL classification: I2, Q020.

INTRODUCTION

Appearance of Covid-19 infection in China at the beginning of 2020 lead to pandemic, which was a big concern for the public health in the whole world for the World Health Association (WHO) (Wen et al., 2020.). The current research has proved the virus has many different forms, different incubation period and can affect people's health in many different ways. Virus Covid-19 is resistant to external factors, easily penetrates into human body and can be lethal. Medical intervention is required for recovery of infected patient (Shen et al., 2020.). For this reason, it is very important to stop further virus spreading in public places (Morse et al., 2020.). Application of adequate measures for virus prevention in places where larger number of people are present is only possible with the full understanding of transmission mechanism and virus sustainability.

As there are not space limits for its spreading, pandemic Covid-19, caused by coronavirus SARS-CoV-2, affects all areas of human life. Covid-19 has big influence on global economy and for this reason; companies in the whole world go through difficult times. Some branches of economy require prioritized measures and help in order to survive.

Regardless to declared emergency situation because of Covid-19 pandemic, people still must function. They need material things, including food. In regards to this, agriculture, food processing industry, distribution and food trade have become prioritized economy branches (Genkin et al., 2020.). There is a big concern in the world that pandemic will lead to long lasting crisis in area of food processing industry (Fei et al., 2020.). Functioning of companies in the above-mentioned sector is crucial for unobstructed food supply for citizens. There are huge negative consequences of Covid-19 in tourism and gastronomy (Hao et al., 2020; Kaushal et al., 2020). Baek et al. (2020) claim that the highest negative effect of pandemic suffered production of oil and natural gas, restaurants and hotels, while production of food and drinks was not affected it such an extent.

Covid-19 has significant impacts on stability in financial sector (Baek, 2020; Heyden, 2020; Liu et al., 2020; Zaremba et al., 2020; Zhang et al., 2020.).

American association of food industry assumes that health system, chain of food supply, food safety, employment services, media and services for acting in emergencies, should get together and offer help for endangered economy sectors (Mayurnikova et al., 2020). In February 2020 Russian service, in charge of consumer protection, developed recommendations with measures for prevention of corona virus infection in food and drink establishments, food storages and educational institutions. (Dolgov and Savinov, 2020); (Mayurnikova et al., 2020.). Companies and institutions developed additional measures for Covid-19 prevention. Mayurnikova et al. (2020). have proposed the practical measures for prevention of pandemic in gastronomy.

Pandemic Covid-19 continually affects changes of education system (Bond et al., 2020.), including higher education too. The new situation influenced the change of environment (place) and the way of performing lessons. Students and teachers are looking for other types of teaching process, while state institutions check on the current systems and processes (Self, 2020.). Changes under pressure in emergency are stressfully for all participants.

Consequences of Covid-19 pandemic are present in all areas of society, including economy, health system and education. It is evident that we need adequate competent people to fight against it. Health – sanitary experts and sanitary engineers have their special place in it, both during preventive activities and in the process of elimination. Their education requires special attention and requires from the higher institutions content that will enable promotion of knowledge and competencies for graduated students. We should encourage promotion of the current study programs at higher education institutions in Republic of Srpska, Bosnia & Herzegovina and surrounding countries through the wide discussions and show that qualitative engineer education can be achieved during big disasters, as Covid -19 pandemic is.

MATERIALS AND METHODS

Methodology procedures in work are based on the previous research in this area and it is available in scientific publications, studies and the other relevant sources published on this topic. During the development of this work, different sources are used: scientific publications, (works published in leading world journals), official regulations, instructions and recommendations of international organizations (WHO) and national authorities, expert bodies and agencies, company's documentation. The following methods, as some of famous and approved research methods from scientific research part for the needs of this work, are used: method of theoretical analysis, method of descriptive analysis of research in collecting, processing and data comparison.

RESULTS AND DISCUSSION

TEACHING DURING PANDEMIC

In the beginning of 2020, education system in most of the countries was threatened by Covid-19 pandemic. In such circumstances, the higher education was exposed to new challenge: it was necessary to maintain teaching process without physical presence of students in classrooms and laboratories, without gatherings of bigger groups of students, with strict compliance of hygienic measures (wearing masks and disinfection of hands) (Self, 2020.). The higher school institutions (higher school institutions) had no sufficient amount of time or none at all to plan and develop new procedures for teaching process. Regardless of this, teachers and students had innovative approach. Teachers used flexibility in just adopted regulations and support of modern technology equipment to offer their students interesting content (Iveland et al., 2020.).

For students of health sciences, the special problem is incapability of organizing practical lessons in health institutions, institutions and factories. State authorities in conjunction with recommendations of World Health Organization, developed instructions for conduct and work in educational institutions, including higher school institutions. Such drastical changes in planning, organization and realization of teaching process have not been seen before. The solution to maintaining teaching process was found in so called „on-line teaching“, which has been known and realized with some study programs that not require work in laboratories and practical lessons, which is a dominant type of teaching at both of faculties of health sciences and medical faculties of natural-technical science. The new approach requires change in attitude of students and teachers. It requires from a teacher to convey their creativity from classroom-laboratory to online teaching.

Measures taken under urgent procedures and applied during summer semester of academic 2019/20 are necessary to be carefully analysed and adapt to teaching process in 2020/21. New academic year will still be challenging. The Ministry for technology development, higher education and computer science of Republic of Srpska (Ministarstvo, 2020a.) has given the new recommendation for teaching. In accordance with classic model, with proposed alternative to have on-line lessons, in case if health–epidemiology situation should be requiring it. For the beginning of teaching in academic 2020/21 year, The Ministry for technology development, higher education and computer science of Republic of Srpska (Ministarstvo, 2020b.) has given the new recommendation. There has been given option of using different environment during teaching process (known as hybrid model, where is allowed that certain number of students is attending lessons in classroom while the others on-line). It is difficult to estimate if it is going to come to termination of teaching process and when and for how many times. Regardless of it, higher education institutions should come up with backup plans and foresee innovative and flexible system of transition from one to another way of teaching process. In order to show insight and guidelines on how to maintain high quality of education during Covid-19 pandemic, Academy of science, engineering and medicine of the USA (Self, 2020.) expressed its attitude in regards to it in their book „Teaching K-12 Science and Engineering During a Crisis“. Some of directives are very acceptable in case of academic education of health-sanitary engineers and authors cited suggestion given in this book for many times.

In the new situation, it is not acceptable to omit the bigger units and content specific for vocational profile. Moreover, it is necessary that process have emphasis of scientific approach, by which vision of quality education of health-sanitary engineers must not change. The professional community and lay people can easily understand and critically analyse every procedure of sanitary experts during pandemic. Higher education institutions should accept that as axiom and put additional effort during education of engineers.

At School for Applied Medical Sciences in Prijedor, the beginning of teaching process in summer semester in academic 2019/20 was classical and did not differ much from teaching in other academic years. However, in the beginning of March in Republic of Srpska emergency situation was in power because of Covid-19 pandemic, which reflected on the further continuation of teaching process. Since that moment, the teaching was organized on-line. Some other problems emerged as inexperience of some teachers and lack of computer equipment. The problems were addressed as the teaching went along and after 2-3 weeks, theory teaching was maintained without any bigger issues. Practical lessons (the work in laboratories) were done in the end of semester, and on the basis of certain instruction of The Ministry for technology development, higher education and computer science of Republic of Srpska (Ministarstvo, 2020a.) The other types of practical lessons (work in hospitals, health institutions and factories) were realized by extreme creativity and efforts of teachers and students and by using modern technology.

The acquired experience should be used for organizing teaching in new school year, which is the aim of this work.

ANALYSIS OF TEACHING CONTENT

Covid-19 pandemic, apart from teaching process, also endangered functioning of economy system in the whole world and Republic of Srpska and Bosnia and Herzegovina were not exemption. Moreover, pandemic has pointed out importance of hygiene, sanitation and disinfection in all areas of human activity and life in general. In the other words, it was additionally emphasized importance of experts in that area (sanitary engineers and experts from associated areas). As there was rise in pandemic so the proportionally there was the higher demand for sanitary professionals in area of public health system, food security in the whole chain of supply, life environment and work environment etc. The emphasis should be on the knowledge of sanitary engineers in public services for disinfection, health institutions, state institutions, educational institutions, production companies etc. Sanitary engineers have important role in development of sanitary protection plans and in system of control and supervision in conducting sanitary measures as a whole.

If we look at scope of work done by sanitary engineers, as before in “normal times“, and now during Covid-19 pandemic and in the future, it is clear that they have to possess the high level of knowledge in different areas. The questions, which arise, are related with the way of their education and their ability to respond to different demands during emergencies, like pandemic.

OVERVIEW OF EXISTING HIGHER SCHOOL INSTITUTIONS

In Table 1. there is an overview of higher school institutions in Bosnia and Herzegovina which educate staff of above mentioned profile. As we can see, there are different levels (180 ECTS, 240 ECTS and 300 ECTS) and types of education (academic and vocational). Further, on, we can see that number of higher school institutions is relatively high and we assume that number of graduates can satisfy the needs either in «normal times» or during emergencies or pandemic.

Analysis, which is dealing with the amount of knowledge that students acquire during education, demand deeper and profound analysis. During overview, we can notice that most of higher school institutions study program content of sanitary engineering (or similar titles and acquired academic/vocational titles after graduation) cover four key areas: public health, protection of life environment, food safety, regulations and administrative law. Out of all mentioned areas, the students have at their disposal more subjects that are updated during vertical education.

Table 1. Overview of higher school institutions in Bosnia and Herzegovina, which educate sanitary engineers

Higher school institutions		240 ECTS	180 ECTS
BOSNIA AND HERZEGOVINA			
PUBLIC INSTITUTIONS		PRIVATE INSTITUTIONS	
1	School of applied medical sciences Prijedor	+	+
2	University of Banja Luka, Faculty of medicine	+	
3	University of Sarajevo, Faculty of health studies	+	
4	University Bihać, Faculty of health studies	+	
5	University of Tuzla, Medical faculty, Department of health studies		
6	School of applied medical sciences Doboj		+
7	University of Mostar, Faculty of health studies		+
8	Pan-European university Apeiron Banja Luka , Faculty of health sciences	+	+
9	University of Vitez, Faculty of health studies	+	+
10	European University Brčko Faculty of health sciences	+	+

TEACHING CONTENT CHANGES

Although curriculum and syllabus ensure sufficient amount of knowledge during classical teaching in a classroom/laboratory, it is necessary to analyse their quality during teaching process in emergency circumstances (on-line teaching). We must keep in mind that emergency situation (so Covid-19 pandemic) demands from sanitary engineers additional knowledge and skills. Knowledge: new knowledge in microbiology, especially in virusology, familiarization with the Corona virus, nature, behaviour, ways of transmission, consequences for people. New knowledge in area of personal and collective protection, measures for prevention of Corona virus transmission and spreading disease. New skills in area of decontamination (washing and disinfection, equipment and measures), handling of personal and collective protection means. New knowledge and skills through methods for defining presence of Corona virus in human body and equipment (PCR and ELISA tests).

The need for quick inclusion in business, from newly graduated students, requires the certain level of experience. High school institutions should analyse certain subjects from teaching content and change it in accordance with the needs. What are these subjects? What are the contents? Do the high school institutions have infrastructure needed for realization of the new content? Are the teachers trained to perform theoretical and practical teaching with new content? Do students experience additional burden with new classes, new content or it is necessary just to omit and replace the certain content? These are just some of questions, which superiors at high school institutions should analyse during promotion of teaching of study program of sanitary engineering and similar programs.

In order to have efficient teaching in emergency situation, during the change of teaching plans and programs, we should adhere to certain principles which refer to quality of education and demands of education. We should also pay attention to demands of achieving high level of students knowledge, interdisciplinary and multidisciplinary approach to knowledge from different areas of sanitary engineering. The knowledge from basic sanitary-health disciplines should be combined with engineer practice and other social standards and state standards. It would be good if teachers, during their classes, could use their sci-

entific approach in solving problems (for example, planning of researches and analysis of obtained data). In the end, one of principles can refer to possibility of adapting to changeable surrounding (place where teaching takes place).

The large number of applications for online teaching support is available. Many applications offer support to research approach, including discussion between teacher and students and within the students in the group. By choosing the application for support of teaching process, we should stick to teaching process objectives and choose application that can offer the best support to students. Quality education should be in focus in each moment (Branch and Dousay, 2015.). Some tools can animate students to thinking and communicating during learning, (Moulding and associates, 2019.). There is a large number of softwares for support of teaching. Teachers should take care that new requests for teaching software could cause student disaffection. It is desirable to include video presentations in teaching contents. Many students do not have access to computers or internet, which aggravates communication with teacher and fellow colleagues. High school institutions and teachers should plan how to enable students to have access to teaching resources. World experience shows that it is useful to offer teaching material out of existing net of high school institutions (World Bank, 2020.). In similar situations, the using of mobile telephones enables access to teaching content. More information about resources, which serve for support in online teaching, can be seen on sites of appropriate agencies (SETDA, 2020).

No matter how hard were the efforts of the authorities, state organs, high school institutions, teachers and students, during the teaching process in conditions in Covid-19 pandemic, there can be various issues. Quite often, teachers need to reduce the amount of teaching materials which they present to students, while they still include all teaching materials anticipated for the given course. Sometimes teachers need to change teaching materials in accordance with technology limitations and student needs. The changes can be made in each lesson, using resources, which are used for teaching, or resources from work environment. (Self, 2020.). Many teachers change their teaching materials on their own. Although the mentioned changes are happening very fast, it is important to ensure that materials still keep focus on good principles of teaching process. If it is necessary, from the above-mentioned reasons, to change volume or sequence of teaching materials, it is very important that students do not get in trouble during learning and taking exams. In order to use the most efficiently the teaching process, teachers can obtain a certain level of help with careful analysis and answers to the following questions (Self, 2020.):

- How to organize lessons in order to be focused on the principal needs of students?
- How can students achieve more learning aims simultaneously?
- In which way can be ensured coordination within a group or more groups of students?
- How can students participate in disciplines that are more academic at the same time, and can they?
- Can accommodation of students in dormitories or other community types of accommodation be helpful in solving the problems?

Development of teaching materials is a very complicated process and it involves teams of experts for development of syllabus and curriculum and teachers of given subjects. The change of teaching contents at high school institutions, in case of emergency situations, is quite often done by subject teachers, and changes are approved by experts for teaching content and authorities of high school institutions (for example, Senate). Management of high school institutions and Senate give guidelines for change of content. The size and type of changes, as having been said, depend on resources, which are at disposal to teachers and students (Self, 2020.). It is necessary to accept the real condition in internet access opportunities for all the students and ensure that all students have equal access to teaching. The listed changes should provide sup-

port to students with disabilities. The changes should follow development of computer and communication infrastructure, training of teachers and technical support staff for development and presentation of new content. There is a pending research on this topic which is conducted by EdTrust and Digital Promise (2020).

The difference between the usual forms is that every academic part is taught independently from other disciplines, in emergency, using possible content overlapping in two or more disciplines (teaching subjects), it is desirable to ensure the high level of coordination of teaching between subjects. Discrete content, which is useful only in one area of work, should be changed with focus on knowledge widely applicable. During the change of teaching content, it is desirable to use the precognition, which students have. If the changes of teaching content are done in an unprofessional way, the lack of time can leave numerous voids in students' knowledge. In order to ensure students' knowledge, high school institutions and teachers should ensure coordination of content volume and sequence in the total teaching content that student need to get in emergency situation during Covid-19 pandemic.

CONCLUSION

Consequences of Covid-19 pandemic are present in all areas of society, including economy, health system and education. In our effort to eliminate disease consequences expert staff –sanitary engineers are included. In Bosnia and Herzegovina and Republic of Srpska there is a larger number of high school institutions that educate professionals of this profile. In order to enable graduated students to respond to needs of society and economy in emergency, they are required to acquire additional specific knowledge and it has to be included in their teaching process.

Pandemic Covid-19 affects the work of high school institutions and way of performing teaching. Taking into account difficulties in classical system of teaching process, high school institutions resorted to online teaching. Apart from the way of performing the teaching, the new situation requires the certain changes in volume and content of teaching subjects. Higher school institutions should abide by accepted principles and keep the high level of teaching quality. With careful and good balanced changes of curriculum and syllabus, higher school institutions is to respond to requirements of times they are working in, the student will get high level of knowledge and skills, and society and economy will get necessary professional experts.

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