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The efficacy of essential oils against *Venturia inaequalis* (Cooke) G. Winter and *Podosphaera leucotricha* (Ellis & Everh.) E. S. Salmon *in vivo*

Tamás HOCHBAUM,[1] Marietta PETRÓCZY,[1]
Márta LADÁNYI,[2] Géza NAGY[3]

[1] Szent István University, Faculty of Horticultural Sciences,
Department of Plant Pathology, 44. Ménesi Str., H-1118 Budapest, Hungary,
e-mail: tamas.hochbaum@gmail.com; Petroczy.Marietta@kertk.szie.hu

[2] Szent István University, Faculty of Horticultural Sciences,
Department of Biometrics and Agricultural Informatics,
29–43. Villányi Str., H-1118 Budapest, Hungary,
e-mail: Marta.Ladanyi@kertk.szie.hu

[3] National Food Chain Safety Office, Directorate of Plant Protection,
Soil Conservation and Agri-Environment, 141–145. Budaörsi Str., H-1118 Budapest, Hungary,
e-mail: nagygez@nebih.gov.hu

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Abstract. Though profitable crop production can be more simply achieved by using synthetic pesticides, the research of alternative plant protection solutions is necessary. The effect of the volatile oils of cinnamon, thyme, and a copper ingredient fertilizer were tested for their activity against apple scab and powdery mildew in apple orchards in 2014 and 2017. Oils applied alone or in combination were effective against apple scab in 2014 and in 2017 and against powdery mildew on leaves in 2017. The copper ingredient fertilizer product improved the efficacy of the oils. The results of these trials show that the tested volatile oils are suitable candidates for further research and for the development of organic fungicides against the diseases of apple.

Keywords: apple scab, powdery mildew, thyme, cinnamon

1. Introduction

Apple scab (*Venturia inaequalis* (Cooke) G. Winter) and powdery mildew (*Podosphaera leucotricha* (Ellis & Everh.) E. S. Salmon) are, among others, the

most important diseases of apple all around the world where apples are grown [6, 19, 20]. These diseases can cause severe damage in Hungarian apple production in epidemic years [10]. Management is mainly carried out by fungicide applications. The number of spraying often exceeds 20–25 treatments in one vegetation period under high disease pressure. In recent years, the use of several fungicides against apple disease is strictly regulated by the EU legislation (e.g. Directive 2009/128/EC, Commission regulations No 834/2013, No 1004/2013, No 1138/2013, No 639/2014). Because of an increasing public demand to reduce the use of synthetic pesticides, it is necessary to research the alternative solutions for plant protection. Essential oils or plant extracts are suitable candidates for this purpose. Their antimicrobial and antifungal activity has been known for centuries, and it is still an intensively studied field. Essential oils contain different kinds of compounds. These compounds are effective against plant pathogens, and they have different modes of action, for example, Sterol Biosynthesis inhibition in membranes [16, 17, 19].

The number of published data on the effect of essential oils and plant extracts on *Venturia* species is low compared to those of available on other plant pathogens, for example, *Monilia* species [12, 14, 22]. Plant extracts containing high contents of active ingredients of artemisinin (*Artemisia annua*), chelidonine (*Chelidonium majus*), menthol (*Mentha piperita*), populin (*Populus nigra*), linalool + linalyl acetate (*Salvia sclarea*), and thymol (*Thymus vulgaris*) were tested against the ascospore and conidia germination of *Venturia inaequalis*. Almost all extracts showed high inhibition of ascospore germination. The 1% *Populus* extract gave similar efficacy against *Venturia* on apple trees as synthetic fungicides in a 2-year field study [3, 18]. Pfeiffer [15] investigated several plant extracts against *Venturia inaequalis* under greenhouse conditions. The extract of *Saponaria officinalis* showed high inhibition of conidia germination.

The effect of volatile oils of thyme (*Thymus vulgaris*) and cinnamon (*Cinnamonum verum*) has been investigated at the Department of Plant Pathology, Szent István University, since 2005 [8, 11, 14]. The inhibition of the essential oils of thyme, cinnamon, and sweet orange on the conidial germination of *Venturia* sp. was investigated *in vitro* in 2015. A wash-off study and a preventive-curative activity of cinnamon oil was assessed as well [9].

According to previous studies [9], the effect of three volatile oils (cinnamon, thyme, and orange) on the conidial germination of *Venturia inaequalis* was tested in three concentrations (0.001%, 0.01%, 0.1%). All tested essential oils suppressed conidial germination effectively at 0.01% and 0.1% concentrations. The highest inhibition level was achieved by thyme oil. Foliar application of cinnamon oil (in 0.2%) was effective against scab on apple seedlings with preventive and curative application timings under controlled conditions. 1 hour or 24 hours before inoculation, the treatments showed almost complete inhibition

(100 to 99% efficacy). Even curative applications showed good disease control (97% and 83% efficacies by 24 h and 72 h curative treatments respectively) [13].

Almeida et al. [2] tested the phytotoxic activity of twelve kinds of essential oil by evaluating the germination and initial radical growth of seeds. Thyme was active against germination and radicle elongation as well. Cseh et al. [7] reported the phytotoxicity of thyme essential oil on lettuce seedlings *in vitro* as well.

The objectives of this 2-year field study were (i) to investigate the biological control effect of the essential oils of cinnamon and thyme independently and in combination with copper containing fertilizer against *Venturia inaequalis* on two apple varieties in 2014, (ii) to investigate the efficacy of cinnamon and thyme applied independently and in combination against *Venturia inaequalis* and *Podosphaera leucotricha* in an apple spray programme in 2017, (iii) to determine the minimum effective dose rate of cinnamon, and (iv) to evaluate the occurrence of phytotoxicity on the host plant.

2. Materials and methods

Essential oils and adjuvants

Essential oils of thyme (*Thymus vulgaris*) (Aromax Inc.) and cinnamon (*Cinnamonum verum*) (Aromax Inc.) were selected for *in vivo* assays. Chemical composition was determined by GC 6890N Gas Chromatograph equipped with 5975 Inert mass selective detector (*Table 1*). According to previous studies [8], Silwet Star adjuvant was added in 0.02% concentration to aqueous essential oil dilutions in order to facilitate the dispersion of the oils. The applied concentration did not influence conidium germination.

Table 1. Composition [%] of the selected essential oils [13]

Component	RT	LRI	Cinnamon (%)	Thyme (%)	Orange (%)
α-pinene	5.56	938	-	0.67	0.31
camphene	5.95	952	-	1.44	-
sabinene	6.52	976	-	-	0.19
β-myrcene	6.99	995	-	1.47	1.25
α-terpinene	7.79	1018	-	2.15	-
ρ-cymene	8.09	1026	1.77	24.58	-
limonene	8.19	1029	0.86	-	97.64
1,8-cineol	8.38	1034	3.58	6.54	-

γ-terpinene	9.2	1056	-	7.42	-
linalool	10.76	1097	3.65	5.5	0.22
borneol	13.43	1162	-	0.63	-
terpinen-4-ol	13.96	1175	-	0.93	-
α-terpineol	14.55	1189	1.12	-	-
phenylethyl alcohol	14.83	1201	1.64	-	-
thymol	18.81	1290	-	40.64	-
carvacrol	19.2	1300	-	3.6	-
cinnamyl aldehyde	20.8	1351	67.9	-	-
eugenol	21.44	1361	6.83	-	-
geranyl acetate	22.43	1388	-	0.52	-
β-caryophylene	23.68	1420	2.5	3.08	-
methyl trans-cinnamate	24.14	1436	2.09	-	-
ethyl cinnamate	24.2	1440	0.75	-	-
α-humulene	25.07	1454	-	0.32	-
cinnamyl-acetate	26.13	1488	6.62	-	-
caryophylene oxide	30.2	1590	-	0.21	-
benzyl benzoate	35.67	1738	0.33	-	-
Total			99.64	99.7	99.61

Note: RT: Retention time, LRI: Linear retention index relative to C_8-C_{23} n-alkanes on a HP-5 column

Test plants and field study

Based on the results of the study carried out by Nagy et al. [13], the efficacy of the oil of cinnamon and thyme was investigated in apple orchards in different combinations. In 2014, the oils were evaluated separately and in combination with a product of copper ingredient fertilizer. The efficacy was compared to the Silwet (untreated) control. In 2017, the oils were also tested separately and in combination with each other. The efficacy was compared to the Silwet (untreated) control and to the efficacy of the integrated pest management programme of the orchard (*Table 2*).

Table 2. Treatments in 2014 and in 2017

Name of treatment	Essential oil concentration	Silwet Star adjuvant (%)
Treatments in 2014		
Cinnamon	0.2%	0.025%
Thyme	0.2%	
Cinnamon + Copper Fertilizer	0.2+0.2%	
Thyme+ Copper Fertilizer	0.2+0.2%	
Silwet control	-	
Treatments in 2017 (Tordas)		
Cinnamon	0.25%	0.025%
Thyme	0.25%	
Cinnamon + Thyme	0.125+0.125%	
Silwet control	-	
Integrated Pest Management Programme	-	
Treatments in 2017 (Nógrád)		
Cinnamon	0.2%	0.025%
Cinnamon	0.25%	
Sulphur 80 WG (a.i. 80%)	3.0 kg/ha	
Untreated	-	

The field trials were carried out on four apple varieties in three orchards near Budapest in 2014 and in 2017. In 2014, the site of the trial was at Érd-Elviramajor, in a 15-year-old apple orchard (varieties: 'Decosta', 'Jonaveld'). In 2017, the efficacy of essential oils was evaluated at two sites. At Tordas, the apple orchard ('Red Jonaprince') was four years old. In order to determine the minimum effective dose, a complementary field trial was also carried out according to Good Experimental Practice (GEP) at Nógrád ('Granny Smith') in a 15-year-old orchard. The training type was slender spindle in each orchard.

The interval between the applications was 5–14 days in 2014 and 2–20 days in 2017. The trees were sprayed in different combinations and timings (*Table 2*, *Table 3*).

Table 3. Details of application, Trial 2017, Tordas

	Date	Time of day	BBCH	Temperature (°C)	Cloud (%)	Wind (km/h)
1.	March 31.	16:00–17:00	BBCH 55	21	0	2
2.	April 8.	9:00–10:00	BBCH 57	13	90	12
3.	April 14.	7:00–8:00	BBCH 61	8	95	2
4.	April 17.	14:00–15:00	BBCH 64	13	100	4
5.	April 21.	15:00–16:00	BBCH 65	12	0	12
6.	April 28.	11:00–12:00	BBCH 67	10	100	2
7.	May 1.	8:00–9:00	BBCH 69	11	0	3
8.	May 4.	11:00–12:00	BBCH 70	20	20	1
9.	May 6.	18:00–19:00	BBCH 71	18	5	1
10.	May 11.	8:00–9:00	BBCH 71	13	0	5
11.	May 13.	17:00–18:00	BBCH 73	22	40	18
12.	May 21.	6:00–7:00	BBCH 74	14	80	15
13.	May 25.	7:00–8:00	BBCH 74	14	50	18
14.	May 31.	20:00–21:00	BBCH 75	24	5	2
15.	June 5.	20:00–21:00	BBCH 75	22	0	2
16.	June 10.	8:00–9:00	BBCH 76	20	20	3
17.	June 18.	19:00–20:00	BBCH 76	23	25	14
18.	June 26.	20:00–21:00	BBCH 77	20	0	2
19.	July 16.	7:00–8:00	BBCH 78	15	50	6
20.	July 25.	17:00–18:00	BBCH 80	23	20	10

Investigated varieties were ‘Decosta’, ‘Jonaveld’, ‘Red Jonaprince’, and ‘Granny Smith’. These varieties have average susceptibility to apple scab, while ‘Red Jonaprince’ and ‘Granny Smith’ are particularly susceptible to powdery mildew. The essential oils were sprayed with 600–1,000 L/ha water volume according to canopy density by a SOLO backpack mist blower.

The efficacy of the essential oils against apple scab was evaluated two times (19th of June, 18th of August) on the basis of pest severity on leaves and on fruit on the 18th of August in 2014. The disease pressure of *Venturia inaequalis* was lower in 2017 because of the dry and hot weather of the season (*Fig. 1*); therefore, the efficacy could be evaluated on leaves once only. Besides the efficacy against apple scab, powdery mildew was also evaluated in 2017 at Tordas on the 10th of June. The pest incidence of powdery mildew on leaves was evaluated on the 9th

of August at Nógrád. The efficacy of essential oils was calculated using Abbott's formula [1] as well.

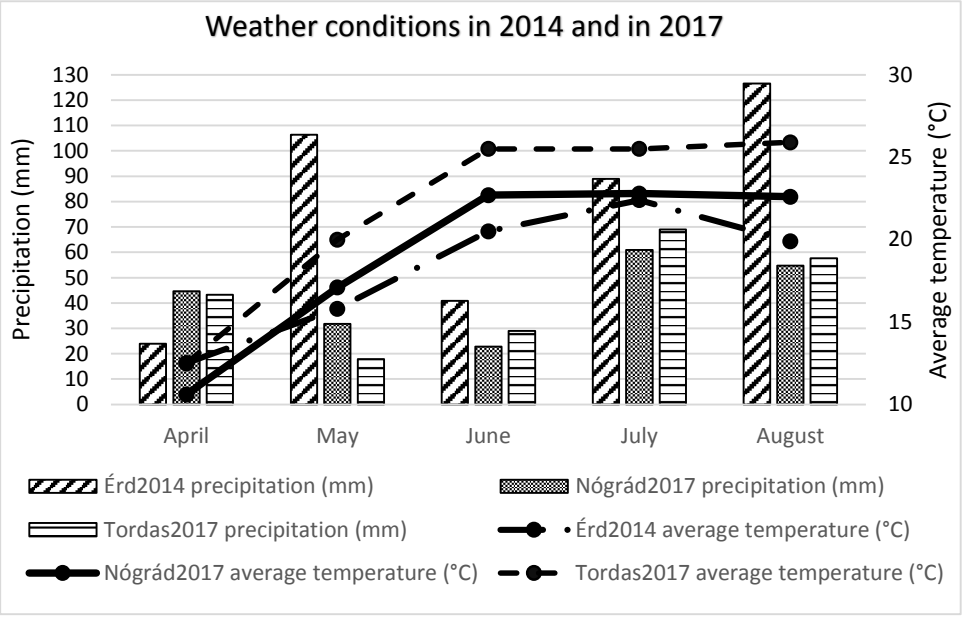

Figure 1. Weather conditions in 2014 and in 2017

Statistical analysis

To compare the treatment effects of essential oils (Silwet control, Cinnamon, Thyme, Cinnamon + CopperFert, Thyme + CopperFert) against apple scab on leaves and the varieties ('Decosta', 'Jonaveld'), a two-way ANOVA with block (= month) design was run with the experiment results of year 2014 (Érd-Elviramajor). To normalize the data, ln(x+0.1) transformation was made. The same comparison regarding the fruits was made by two-way ANOVA.

The treatment effects against powdery mildew and apple scab was analysed by one-way ANOVA based on the experiments of year 2017 (Tordas) using ln(x+0.1) and 1/sqrt(x+0.1) transformation respectively. The normality of residuals was accepted according to their skewness and kurtosis since their absolute values stayed below 1. Homogeneity of variances was accepted by the low variance ratios considering also that the sample sizes were homogeneous in the compared groups. Group separation was made by Tukey's post-hoc test.

Pest incidence of powdery mildew on leaves (Nógrád) was compared by Marascuillo's procedure for independent proportions.

3. Results and discussion

Efficacy of essential oils – 2014

Because of the weather conditions (temperature and the amount of precipitation in spring and summer), the disease pressure of apple scab was high in 2014. Disease severity was 19.5% on 'Decosta' and 19.4% on 'Jonaveld' on leaves in the untreated (Silwet) control block at the second assessment. Both treatment and variety effects were significant ($F_{treatment}(4;989) = 35.25$ $p < 0.001$; $F_{variety}(1;989) = 103.97$, $p < 0.001$). On the variety 'Jonaveld', all of the essential oils reduced significantly pest severity, and the oil of thyme gave the highest effectiveness (Pest severity: 0.9 %; Abbott: 95.4%). On the variety 'Decosta', all of the treatments reduced disease severity, but only the combinations with the copper fertilizer product had significant effect. Thyme + copper fertilizer product gave slightly higher efficacy (pest severity: 6.5%; Abbott: 70.3%) than the cinnamon + fertilizer combination. The effect of the essential oils depends on many factors, i.e. weather conditions, disease pressure and the plant, i.e the variety. The copper fertilizer product could increase the effectiveness of the oils only on the variety 'Decosta'. The volatile oils reduced the pest severity of apple scab on 'Jonaveld' with higher efficacy than on 'Decosta'. The differences between the varieties were significant in each treatments, except in the untreated (Silwet) control blocks (*Fig. 2*).

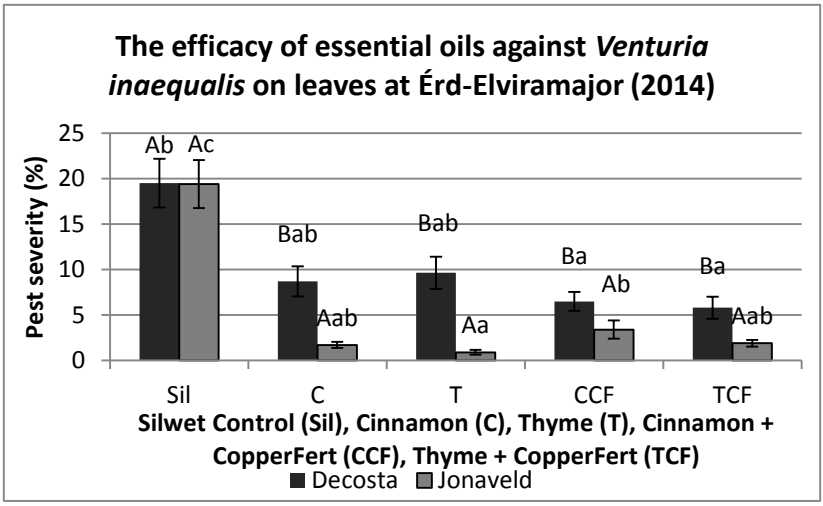

Figure 2. The efficacy of essential oils against *Venturia inaequalis* on leaves at Érd-Elviramajor (2014). Different letters are for significant differences; lowercase: between the treatments within the same variety; uppercase: between the varieties under the same treatment (Tukey's $p < 0.05$).

Although disease severity was lower on fruit than on leaves in the untreated control blocks (3.94% on 'Decosta' and 4.86% on 'Jonaveld'), the efficacy of the oils could be assessed. Both treatment and variety effects were significant ($F_{treatment}(4;490) = 8.11$, $p < 0.001$; $F_{variety}(1;490) = 5.53$, $p < 0.05$). All of the oils were effective against the pathogen. The fruit susceptibility of the varieties differed from each other. The oil of cinnamon in itself was significantly effective only on the variety 'Jonaveld' (pest severity: 2.6%; Abbott: 46.5%). The volatile oil of thyme reduced disease severity, but its efficacy was not significant. The treatment of the oils in combination with the copper fertilizer product could reduce significantly the disease severity on both varieties. Cinnamon in combination with the fertilizer product gave higher efficacy on fruits of 'Jonaveld' (pest severity: 2.1%; Abbott: 56.6%). There were not significant differences between the varieties in the same treatment (A) (*Fig. 3*).

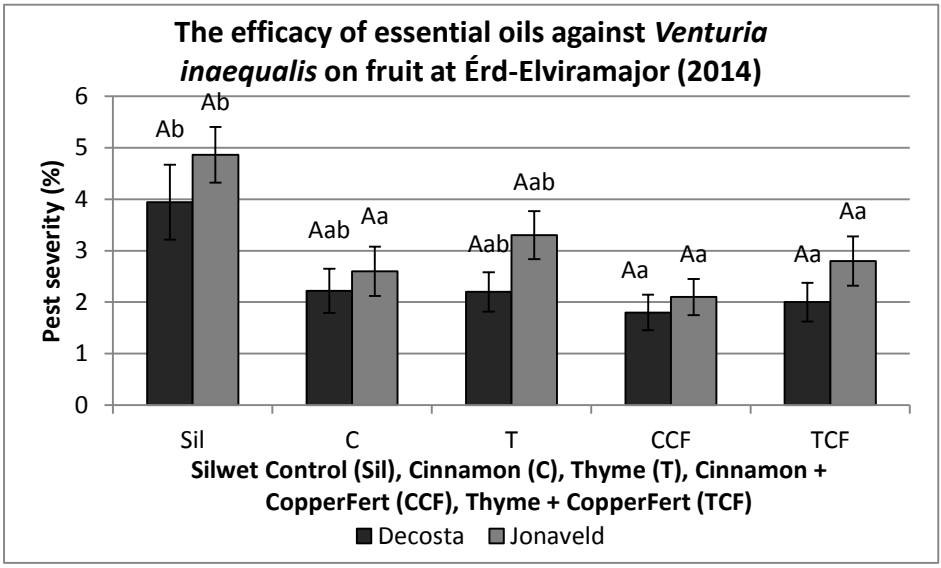

Figure 3. The efficacy of essential oils against *Venturia inaequalis* on fruit at Érd-Elviramajor (2014). Different letters are for significant differences; lowercase: between the treatments within the same variety; uppercase: between the varieties under the same treatment (Tukey's $p < 0.05$).

Efficacy of the essential oils – 2017

Tordas

Venturia inaequalis

Because of the dry and hot weather in May and in the summer, only the early infection of the pathogen could be assessed on the 10th of June. The disease severity (3.5%) in the untreated (Silwet) blocks was lower than in 2014, but the disease incidence (52.7%) was comparatively high. The treatment effect was significant ($F_{treatment}(4;745) = 40.91$, $p < 0.001$). All the tested volatile oils could significantly reduce the pest severity of the pathogen. The difference between the efficacies of the oils was not remarkable under lower disease pressure. The most effective control was achieved with thyme oil (pest severity: 1.44%; Abbott: 58.9%). Bálint *et al.* [3] and Thiesz *et al.* [18] found thyme extracts effective as well. The integrated pest management (IPM) programme showed the highest disease control (pest severity: 0.23%; Abbott: 93.4%; *Fig. 5*).

Podosphaera leucotricha

The weather condition was more favourable for powdery mildew (untreated (Silwet): severity 7.64%, frequency 59.3%) than for apple scab in 2017. The treatment effect was significant ($F_{treatment}(4;745) = 23.49$, $p < 0.001$). All tested volatile oils could reduce the pest severity of powdery mildew significantly. Neither antagonist nor synergistic effect of the oils was observed. The efficacy of thyme oil applied alone was slightly higher (pest severity: 2.45% Abbott: 67.9%) than that of other oil treatments. The integrated pest management (IPM) programme showed the best powdery mildew control (pest severity: 0.4%; Abbott: 94.8%) (*Fig. 5*). A curative effect of cinnamon oil was observed as well (*Fig. 4*).

Figure 4. Curative effect of cinnamon oil against powdery mildew on 'Red Jonaprince'

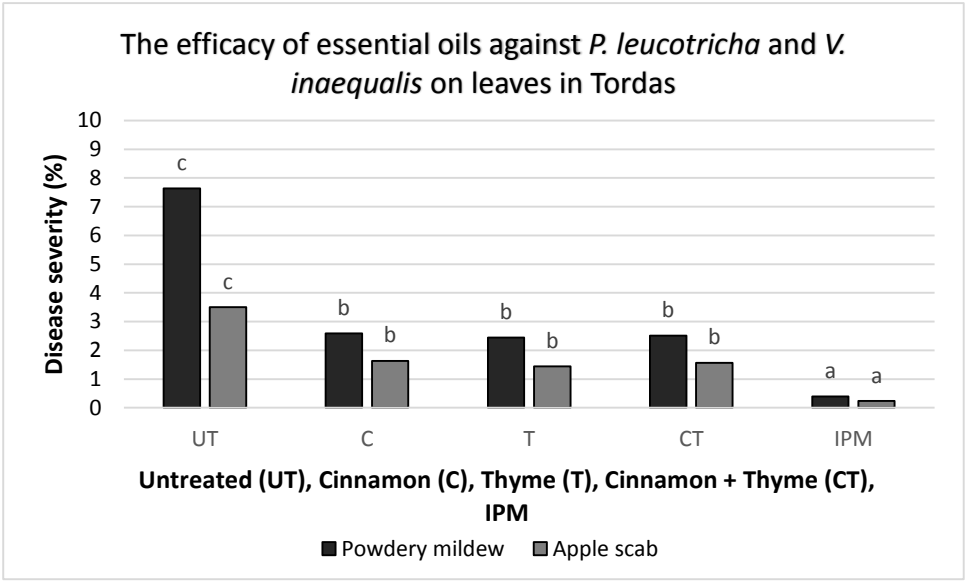

Figure 5. The efficacy of essential oils against *Podosphaera leucotricha* and *Venturia inaequalis* on leaves in Tordas (2017). Different letters are for significant differences (Tukey's $p < 0.05$).

Nógrád

The pest incidence of powdery mildew was 80.0% in the untreated control blocks at Nógrád. According to Marascuillo's procedure, all of the treatments reduced significantly the disease frequency on leaves compared to control ($|rf_{control}\text{-}rf_{treated}| > 0.28$; $p_{Chisq(3)} < 0.05$). Cinnamon in 0.25% gave the highest disease control on leaves (pest incidence: 38.5%; Abbott: 51.9%). Its efficacy was better than that of the applied commercial Sulphur product (pest incidence: 39.5%; Abbott: 50.6%); however, the difference was not significant ($|rf_{cin0.25}\text{-}rf_{Sulphur}| = 0.01$; $p_{Chisq(3)} > 0.05$). There was no significant difference between the two concentrations of cinnamon oil, though there was some deviation detected (($|rf_{cin0.25}\text{-}rf_{cin0.2}| = 0.14$; $p_{Chisq(3)} = 0.05$). According to the minimum effective dose test, the minimum necessary concentration for an effective control of *Podosphaera leucotricha* is 0.2%. In higher disease pressure, 0.25% is necessary to provide sufficient control of the disease (*Fig. 6*).

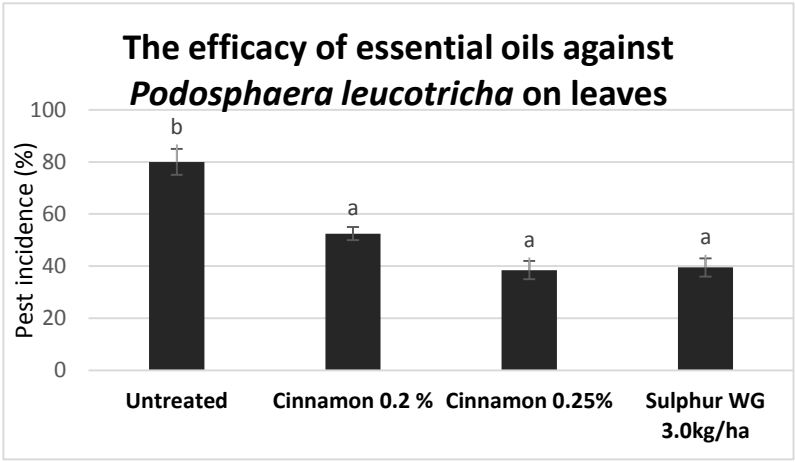

Figure 6. The efficacy of essential oils against *Podosphaera leucotricha* on leaves at Nógrád (2017). Different letters are for significantly different groups (Marascuillo's: $p < 0.05$).

Phytotoxicity to apple

A slight phytotoxicity of thyme essential oil on leaves was recorded at a very low level (frequency 2%); however, only on variety 'Red Jonaprince' in 2017. The symptoms appeared at first 3–5 days after application as a discoloration only on leaves. Later, they passed into necrosis, local death of the tissues (*Fig. 7*). Almeida et al. [2] also found that thyme may cause phytotoxicity. The oil did not cause any damaging symptoms on varieties 'Jonaveld' and 'Decosta'. Cinnamon oil was not phytotoxic to any of the varieties.

Figure 7. Symptoms caused by thyme oil on variety 'Red Jonaprince'

4. Conclusions

In this study, we have demonstrated that the essential oils of cinnamon and thyme are effective against *Venturia inaequalis* and *Podosphaera leucotricha* under orchard conditions. The difference between the efficacies of the oils was less remarkable in 2017 under lower disease pressure. The effectiveness of the same treatment on the different varieties differed from each other. The highest reduction of pest severity by the volatile oils could be observed on variety 'Jonaveld'. According to Berngtsson et al. [4, 5], the variation of effectiveness of the same oil on the different varieties might be explained by the influence of plant defence mechanism. In the minimum effective dose test at Nógrád, cinnamon reduced significantly the amount of infected leaves even in the lower applied concentration (0.2%). The efficacy of cinnamon oil against powdery mildew was comparable with the sulphur ingredient commercial fungicide. In accordance with our previous work on *Venturia inaequalis* [13], cinnamon oil had a strong curative effect against *Podosphaera leucotricha*. The copper ingredient fertilizer amplified the control level of the volatile oils against apple scab, mainly on fruits. The effectiveness of the essential oils depends on many factors, i.e. weather conditions, disease pressure, and the variety. Phytotoxicity could be observed only on the leaves of the variety 'Red Jonaprince' treated with thyme oil. The results obtained in this study showed significant activity of the oils of thyme and cinnamon in the control of apple scab and powdery mildew in 2014 and in 2017 *in vivo*. These essential oils could be suitable candidates for the development of biofungicides against apple scab and powdery mildew.

Acknowledgements

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Automated evaluation of agricultural damage using UAV survey

Daniel STOJCSICS, Zsolt DOMOZI, András MOLNÁR

Institute of Applied Informatics, John von Neumann Faculty of Informatics,
Óbuda University, Hungary,
e-mail: stojcsics.daniel@nik.uni-obuda.hu; mr.zsolt.domozi@ieee.org;
molnar.andras@nik.uni-obuda.hu

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Abstract. In the last decade, the rate of the industrial usage of fixed-wing and blended wing aircraft has increased. A 1–2-km^2 area can be surveyed by such a drone within 30 to 60 minutes, without any special infrastructure, and this can be repeated at any time. This provides an opportunity to conduct automatized surveys and time series data testing, which can be used as a basis to decide specific processes. The state and the development of the plants can be monitored as well as the spread of pests and the efficiency of the procedures that protect against them. During the surveys, thousands of images are taken of the area, which can be converted to a georeferenced large-sized map within 20 to 40 hours, including post-production and a resolution varying from 0.01 to 0.1 cm/pixel. The paper provides a solution to the industrial post-production of these high-quantity data, in which a deep learning-based automated process using Matlab is presented, including a comparison of the results to the GIS data.

Keywords: deep learning, convolutional neural network, UAV, Matlab, survey, precision agriculture, game damage, time series

1. Introduction

In the construction industry and in agriculture, the demand for drone-based aerial mapping supplementing classical surveying technology and partly replacing it has increased in recent years. The drone family of larger companies, such as Parrot / Sensefly eBee or the Trimble UX5 fixed-wing drone aircraft, provide an easily available alternative to man-led, still expensively operated aerial mapping using large aircrafts.

Of course, the prepared systems also have an open-source alternative, such as the ArduPilot drone controller, which we, too, have been using for years. The technological basis of every solution is identical. On-board intelligence is provided by a microcontroller-led on-board unit, which is supplied with the sensors necessary for flying such as GPS and a barometric air velocity and height measurement device. Using a modem, the telemetry connects to the land server unit, to the GCS, which is generally the software running in a Windows or Linux environment. The most popular software package for ArduPilot is the Mission Planner software package. The robot controller is built into an aircraft selected specifically for the work.

Flying wing aircraft with 1–2-m wingspan proved to be particularly suitable for conducting such type of tasks as they are practically composed of only one swept-back wing and of a tiny body.

The operation, in other words, the take-off and landing is conducted from the side of the area to be surveyed, mostly from a road of the width of only one car, without any solid surface. As the basic component of these aircrafts is EPO foam (which, if necessary, is strengthened with a composite material), it can easily endure harder landings with damage. Physical damage can generally be repaired easily and fast between two flights. If a more serious damage occurs, it can be remedied easily by replacing the part with a spare one.

Generally, the sensor managing the remote control is placed inside the body of the aircraft in an area protected from weather. When taking RGB images, this is possibly a converted compact camera with a 16 to 28 megapixel resolution. When conducting multispectral measurements, this can also be a NIR or an imager operating within the main area, such as the FLIR DUO R or the TETRACAM ADC Micro, used in such cases by us.

Depending on the utilized imager and the field resolution to be achieved, flight altitude is chosen. In the case of an RGB orthophoto output agricultural survey, we used a Canon S100 camera whose resolution is 12 megapixel, its sensor size is 1/1.7” and 2.3 fps, and it is capable of capturing a full-resolution still image. We provided the camera with CHDK firmware, to which we created a unique script. As a result, when reaching the desired flight altitude, the machine selects a short shutter speed and takes intensely bright, sharp images until landing. Our chosen flight altitude for 3 cm/pixel field resolution was 150 m.

In this way, there will be a 60% to 70% longitudinal and latitudinal overlap, which is excellent for photogrammetry. During the flight, GCPs are also surveyed, which is done by hand-held GPS results within 5 to 10 m by applying DGPS results in < 1 m accuracy. It is important to mention that when surveyed locally, the accuracy of the images georeferenced using a regular GPS device turns out to be around 1 m too, only that they have a 5- to 10-m offset error compared to reality. This means that the area data measured at the output become practically identical to those having georeferenced by DGPS.

The output contains thousands of images, which can be converted into a georeferenced orthophoto within 20 to 40 hours using a PC with high-end GPGPU.

Generally, 30 to 60 minutes are needed to survey a 1- to 2-km^2 area, including the survey of GCPs, and in this way it can be repeated weekly. Based on the time series analyses, the exact time and reason for the development of certain diseases during the growth of the plant can be determined, just like the size of the damage and its process.

During our examination, we surveyed a given agricultural area several times. We detected the exact level and location of the damage, which were used as bases for protection measures. Our analysis was partly manual and partly automatized. In the following sections, we will introduce a deep-learning-based new examination technology, which can be used to accelerate processing and to make it easier at the same time.

2. Materials and methods

A. Deep learning

An artificial neural network is a type of mathematical model which is based on biological observations. Its main application area is machine learning, whose aim is to set up a system for these networks and to become capable of learning. Considering its structure, a neural network is a graph-based model and its basic elements are neurons which communicate with one another.

The model of the neuron used today is based on Hebbian learning, which describes that learning is not a passive process, but it is the composition of the physiological processes occurring in the biological network.

An artificial neuron is the elemental computing unit of the neural network; it is a much more simplified model of the biological neuron. Generally, we build layers of artificial neurons, and in this way neural network calculations can be described by matrix operations. The type of the layer is determined by what operation it conducts, while, on the other hand, network architecture is determined by the type, the number, and the order of the applied subsequent layers [1].

The layers managing typical tasks can also be the following:

1. Fully connected: creates the combination of the input and the stored weight matrix (1):
$$H = XW + b, \tag{1}$$
where x stands for input matrix, w for weight matrix, and b is an optional weight vector for translation.
2. Recurrent: it recovers its own output per input (2):
$$H_t = XW_x + b_x + H_{t-1}W_h + b_h, \tag{2}$$

where X is input matrix, W_x and b_x are the weights belonging to it, H_{t-1} is the previous output, and W_h and b_h are the weights belonging to it.

3. Convolutional: there is no full connection – the neurons only receive a part of the input. It conducts cross-correlation using the weight matrix of the neurons on the input matrix (3):

$$H = X * W + b, \tag{3}$$

where * marks the cross-correlation.

Neural networks are composed of three logical units:

1. Input layer: it forwards input data towards other parts of the network. The number of neurons is determined by the size and shape of the input data.
2. Hidden layers: also called inner layers whose task is to transform input information.
3. Output layer: the output function and the number of output neurons are determined by the nature of the given problem.

By increasing computational capacity, more complex architectures appear, which contain more and more layers and junctions. By increasing the depth of neural networks, the ability for abstraction increases, and the layers on different depth levels become capable of managing more and more complex tasks. Deep learning is essentially a term for a highly complex neural network which is capable of providing the expected output to complex inputs [2], [3].

CNNs can be utilized well for analysing top-down photos. Top-down photos can be satellite photos or aerial photos too. The former ones are only available for research purposes in a resolution which does not make it possible to draw conclusions of any kind regarding the given area [4]. One characteristic of aerial photos is that they are usually taken for a well-defined purpose at identical heights, using identical camera settings. The purpose can be to analyse a specific agricultural land, to track down areas [5] contaminated by weeds, or to search for any other kind of changes.

The search for lesions is usually conducted involving persons having professional qualifications and experience, and it demands time-consuming manual work besides significant costs. On the contrary, CNN networks provide a new opportunity for analysing images, as it can be managed using CNNs too.

For CNN-based analyses, unmanned aerial vehicles (UAV) are ideal to produce the necessary images because, besides low costs, they are capable of taking photographs of a relatively large area, and the quality of the produced images is ideal for further utilization, as shown in [6], [7], [8], and [9].

In order to analyse the image material collected in this manner, search samples must be defined. These samples can originate from the actual or from a previous survey – it is more important that a large number of training samples be available.

For CNNs, training samples can be quickly managed, and from that point on CNNs can be used to analyse survey images. Naturally, in this case too, the assistance of the expert of the area is many times indispensable; however, this is necessary for a much shorter amount of time, only until defining training samples.

Considering its field of use, it is an exceptionally diverse area where CNN-based image analysis can be used with a result and where a conclusion can be drawn regarding the actual area based on any aspect. In this way, it is even suitable for searching for fungal infections in agricultural lands or even before starting cultivation to classify seeds [10], [11]. In cultures representing an exceptionally high value, it is capable of revealing the deficiencies of the vegetation and even of quantifying it. In this way, for example, a significant profit increase can be achieved in tobacco production areas [12].

By using CNNs, a search can be conducted in areas under cultivation, and even animals present in their environment can be searched for. Thus, the approximation of the population growth of pests and their classification become possible [13].

B. Game damage

The exact establishing of the damage in large-sized agricultural areas, even of several km^2, is an extremely difficult task from the side of the land. The state of the land is mostly approximated based on local sampling by experts, but this is not at all an accurate process. In case of damage, the larger the interest of the owner, the bigger the interest of the insurance company is to establish a smaller value. Accurate data can be provided by aerial photography and not only momentary but temporally changeable rates can also be monitored.

C. Gopher nest detection on wheat field

In the summer of 2015, gophers caused damage to a field of wheat which has been surveyed several times. They were able to completely destroy a 1 to 5 m^2 area of the young plant around the nest. Using the classical GIS method, we calculated and localized the number of nests and their position. The reference manual measurement was made in ArcGIS, as seen in ***Fig. 1***.

Using the exact position of gopher nests, rodenticide is possible to be applied since only local – nest-wise – application is allowed (Par. 2(1) of the Ministry of Agriculture and Rural Development 43/2010. (23 April) on plant protection orders protective measures taken against gophers by farmers and other land users).

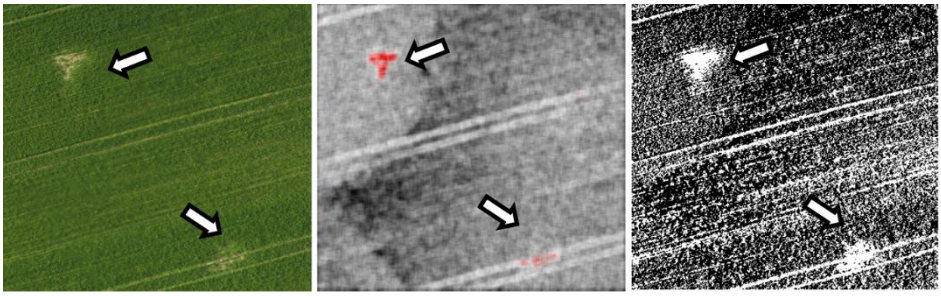

Figure 1. Reference measurement on wheat field – gopher nests marked with arrows

The survey was done on April 24th, 2015, and the full nest count was 56. By repeating the survey one month later, we experienced that the protection measures had been successful (*Fig. 2*). The number of nests has not increased; moreover, the damage has not escalated either. During our previous analysis, we conducted nest detection using a method based on image processing [14], but after some initial successes we found out that the procedure can be used successfully only in the given test case.

Subsequently, we turned towards a procedure which is neural-network-based. Based on a given number of well-chosen training samples, it is capable of detecting feature areas (nests) even outside the test area. Deep learning in a classical sense is based on a large number of training samples, which, after the network has learned them – in other words, stored the relevant information using its neurons from the hidden layers –, it is capable of classifying images which are newly entered and still unknown as inputs.

In our case, the goal is to use CNN in such a manner that we choose a given type of irregularity in the high-resolution images, which in the given case have been taken at different times, and then we detect it. However, we do not provide a large number of samples to the network as usual ([15], [16], [17]), but we choose a small number of positive and negative training samples randomly. In practice, this means 10 to 20 samples per class. One of the classes is the searched sample, the other 2 to 3 classes are agriculturally different features but have similar attributes in the RGB domain, analysed from an informatics point of view.

If the irregularity that is searched for is a gopher nest, then a training sample against it is, for example, a furrow track, an unsown furrow, and a gully. Examined in the RGB domain, these all constitute similar classes, but when examining their structure and contour they constitute different and clearly identifiable classes.

Figure 2. Gopher nest after prevention

D. R-CNN Gopher nest detector

Region-Based Convolutional Networks (R-CNN) use a small number of random samples. According to our theory, the operator only has to enter a few, clearly detectable training samples on the searched feature in the large-sized orthophoto, or rather the same number of similar features which are not from the same class as the searched pattern (*Fig. 3*).

The CNN is composed of 11 layers. The size of the input layer is 32 x 32 pixels by applying the RGB colour channel. Several convolutional layers will be in the intermediate layers, whose width and height determines the filter size the training procedure uses while scanning the images. In our case, we applied 32 filters per layer, which means that the same number of neurons connect to the only identical part of the input. This parameter determines the number of feature maps.

This layer is always followed by a Batch Normalization layer, which normalizes the activations and gradients propagating through a network, making network training an easier optimization problem. Applying the layer, the neural network can be made faster.

The next layer is a non-linear activation function, more precisely the Rectified Linear Unit (ReLU). A ReLU layer performs a threshold operation to each element of the input, where any value less than zero is set to zero (4).

$$f(x) = \begin{cases} x, & x \geq 0 \\ 0, & x < 0 \end{cases}. \tag{4}$$

The network also contains a Max Pooling Layer, whose task is a down-sampling operation that reduces the spatial size of the feature map and removes redundant spatial information. The result of the reduction is that the number of filters can be increased; in this way, we can create a deeper network without the increase of the necessary computing power.

The Fully Connected Layer, as its name suggests too, is a layer whose neurons are in connection with all the neurons of the previous layer. It can combine the simpler features already learned by the previous layer, and it is capable of producing an even more complex conclusion for the sake of classifying the images.

The last two layers are the Softmax and the Classification Layer. Their task is to normalize the network output and, based on the probabilities of the network, to provide the class which belongs most to the image at the output.

The whole R-CNN with 11 x 1 layer array with layers:

1. Image Input, 32 x 32 x 3 images with “zerocenter” normalization;
2. Convolution, 32 filter, 3 x 3 convolutions with stride [1 1] and padding [1 1 1 1];
3. Batch normalization;
4. ReLU;
5. Convolution, 32 filter, 3 x 3 convolutions with stride [1 1] and padding [1 1 1 1];
6. Batch normalization;
7. ReLU;

8. Max pooling, 3 x 3 max pooling with stride [2 2] and padding [0 0 0 0];
9. Fully connected, 128 fully connected layer;
10. ReLU
11. Fully connected, 4 fully connected layer;
12. Softmax;
13. Classification output, crossentropyex.

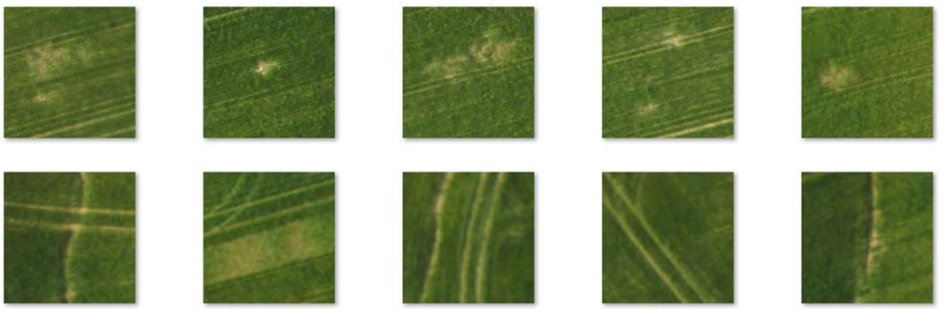

Figure 3. Training samples – upper line: gopher nest, bottom line: not gopher nest

3. Conclusions

Tests have been conducted examining the training time and the classification of the R-CNN.

Test PC:

- Operating system: Windows 7 SP1 64bit,
- Processor: Intel i7-3820 @3.60 GHz,
- Number of physical cores: 4,
- Number of logical processors: 8,
- Memory: 32GB DDR3,
- GPU: NVidia GeForce GTX TITAN Black 3GB.

Generally speaking, because of the low number of training samples, the training, using CUDA GPGPU acceleration [18], is expressly rapid: it is finished within 5 minutes (depending on the size of the regions selected for training purposes). In comparison, detection is much slower.

In case of full resolution orthophotos, which consist of 27,000 × 17,000 pixels [19], the processing time generally fluctuates around 30 minutes per image. The R-CNN was successfully trained in the mentioned way, in a way that during its run it is capable of detecting gopher nests with above 80% accuracy. Due to counter-

training samples, we managed to reduce the number of false detections to zero (*Fig. 4*).

Generally speaking, although the created method was originally designed for a large number of training samples, in this case, it was still applicable. During our work, we analysed the construction of R-CNNs, and we created the layer order that seemed to be the most ideal for our task, including its parameters.

Figure 4. Detected gopher nests, no false detections

During the test, we processed large-sized georeferenced orthophotos and proved the validity of the procedure. The next task is to increase the reliability of the created method, or rather to increase match accuracy (above 95%).

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Soil loss susceptibility model of the Baraolt Depression

Levente CSISZÉR,[1] Ştefan BILAŞCO[2]

[1] Department of Horticulture, Faculty of Technical and Human Sciences,
Sapientia Hungarian University of Transylvania, Cluj-Napoca,
e-mail: csiszer.levente@ms.sapientia.ro

[2] Faculty of Geography, Babeş–Bolyai University, Cluj-Napoca, Romanian Academy,
Cluj-Napoca Subsidiary, Geography Section, e-mail: stefan.bilasco@ubbcluj.ro

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Abstract. The soil loss susceptibility model, made for the Baraolt Depression, offers useful information for the farmers regarding the areas that should be used in a certain way and for a certain purpose, with farming methods which aim at the protection of their most important means of production – soil.

Keywords: R.U.S.L.E., rainfall-runoff, slope length, erodibility factor, land use, quantitative analyses

1. Introduction

Soil erosion can be defined both as a natural process and as a process induced by the activity of the human society, which interfere and have a negative impact on the current evolution of the pedosphere. The factors of this process can be grouped into dynamic factors, such as the kinetic energy of the water, both dropping and flowing down the slope, and static factors such as the properties of the soils or land use.

In Romania, concerns regarding the quantity of the eroded and transported soil started in the 1960s, and the most used model was the one developed by Moţoc M. in 1963. This model was continuously improved up to 2002 [2].

At the global level, the interest in soil erosion loss started around the 1930s – the great dust bowl in the States. This event triggered a real race in soil loss research. A research network was established for collecting the necessary data. In 1940, R. W. Zingg [17] was the first researcher who suggested a mathematic model which made possible the calculation of the quantity of soil loss based on the length and declivity of the slopes. Similar models were made by Dwight Smith in 1947, G. H. Browning

and collaborators in 1947, and Lloyd Eley in 1952 [8] – quoted by Bilaşco Şt. and collab. (2009) [2]. Up to 1960, more models were made, some including in the equation, besides the length and degree of the slopes, other soil loss factors such as the type of the soil, the quantity of the organic matter in it, the consistency of the vegetation, and used farming methods.

In 1965, Wischeimer and Smith published in the *Agriculture Handbook of the United States Department of Agriculture (U.S.D.A.)* no 282 a model, an equation to calculate the quantity of soil loss, which was used from 1960 by the Department and proved to be the most comprehensive ever made up to that time [16].

This equation entered into the science under the name of U.S.L.E (Universal Soil-Loss Equation).

Following the accumulated experience and the development of the mathematical modelling, the equation was revised and upgraded, and so R.U.S.L.E. (Revised Universal Soil-Loss Equation) was published. A remarkable contribution to it was done by K. G. Renard, who published the new equation in 1985 [15]. The R.U.S.L.E. equation analyses each soil-loss contributing factor [1], but, as the calibration was done in Anglo-Saxon measurement units, it was hardly usable in European countries. The adaptation to the metric system was done in 1992, and thus EUROSEM (European Soil-Erosion Model) appeared [19].

2. Materials and methods

To realize the soil loss model of the Baraolt Depression, the first thing we did was to mark the limits of the depression as many geographers, geologists, and geomorphologists consider this area an extent appendix of the Braşov Depression. We did not use just one criterion for delimitation but several ones such as: petrological (Mesozoic rocks on the surface), tectonic (faults), geomorphological (upper glacis on the slopes), vegetation (beech tree forests), land-use (plough land vs grazing land) [4].

In calculating the quantity of soil loss under different terrain conditions, the R.U.S.L.E. [18, 20, 21] equation uses five factors which represent the quantification of a specific condition that influences the gravity, seriousness of soil erosion on that terrain. The form of the equation is:

$$A = K \times Ls \times S \times C \times Cs,$$

where:
A – quantity of the soil loss in t/ha/year,
K – rainfall-runoff erodibility factor,
Ls – slope length and steepness factor,
S – soil erodibility factor,
C – land-use factor, and

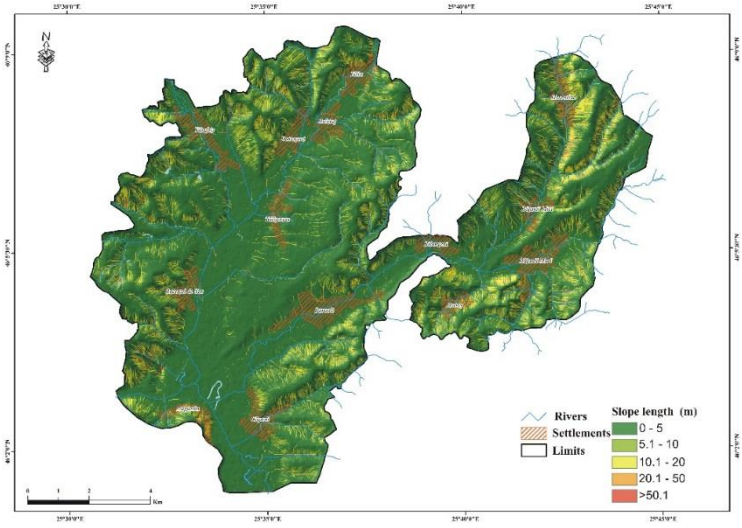
Cs – correction factor.

To elaborate the soil loss model for the Baraolt Depression using G.I.S. technics, we followed the model used before by Moore I. D., Wilson J. P. (1992), Mitasova H. et al. (1998), Mitasova H., Mitas L. (1999), Patriche C. V. et al. (2006), and Filip S. (2008) [11, 9, 10, 14, 7]. Accordingly, we needed a database for each factor of the equation.

Regarding the K factor, there are studies to calculate its value using the rainfall quantities or annual average values or monthly high values. The value of the factor can be precisely calculated just experimentally, on specially arranged parcels and applied to extended areas which are homogeneous from a climatic point of view.

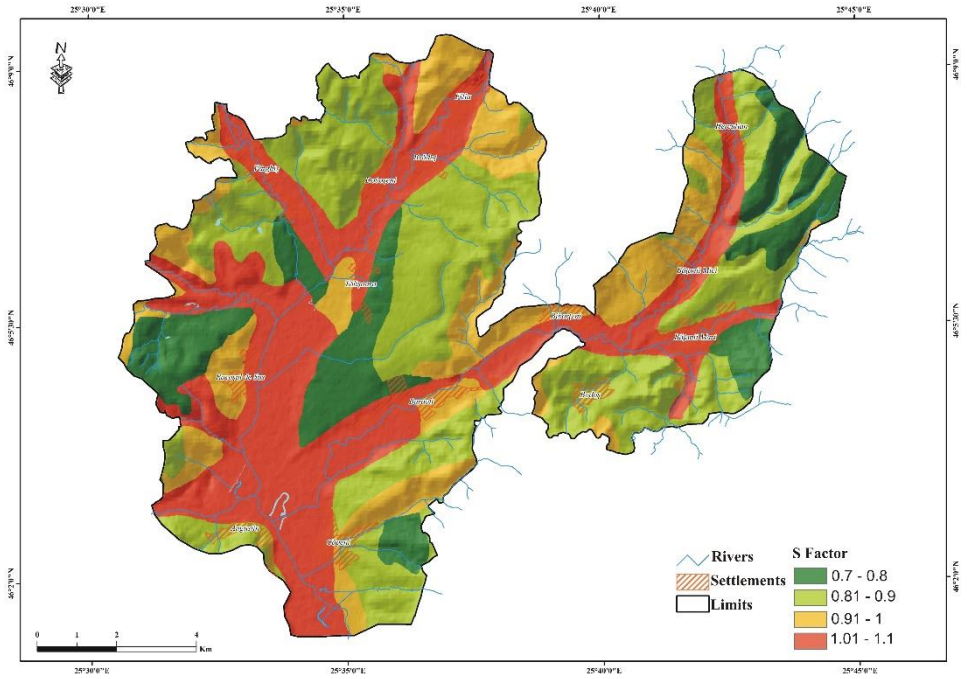
For Romania, the values were calculated by Moţoc M. et al. (1975) [12], who extended from 33 MJ mm/ha/h/year for the Western Plains to 102 MJ mm/ha/h/year for The Southern Carpathians and The Curvature Carpathians. We used the latter value in the equation.

Slope length and steepness factor *Ls* was produced by elaborating the slope map of the Baraolt Depression using ESRI ARCINFO platform. First, we created the slope steepness map using a resolution of 5 m. It was impossible to make a better resolution as we used a 1:25,000 scale map as topographic database. According to this, we started to make a classification of the steepness and of the length of the slopes [4]. The best classification that reflects also the reality on the field was: 0–1.99°, 2–5.99°, 6–9.99°, 10–14.99°, 15–24.99°, and over 25° for steepness, while for slope length: under 5 m, 5.1–10 m, 10.1–20 m, 20.1–50 m, and over 50 m. We applied these classifications to the slope maps and made the soil loss susceptibility map according to the slope steepness and length (*Map no. 1*).



Map 1. Susceptibility to soil loss according to the slope length and steepness factors

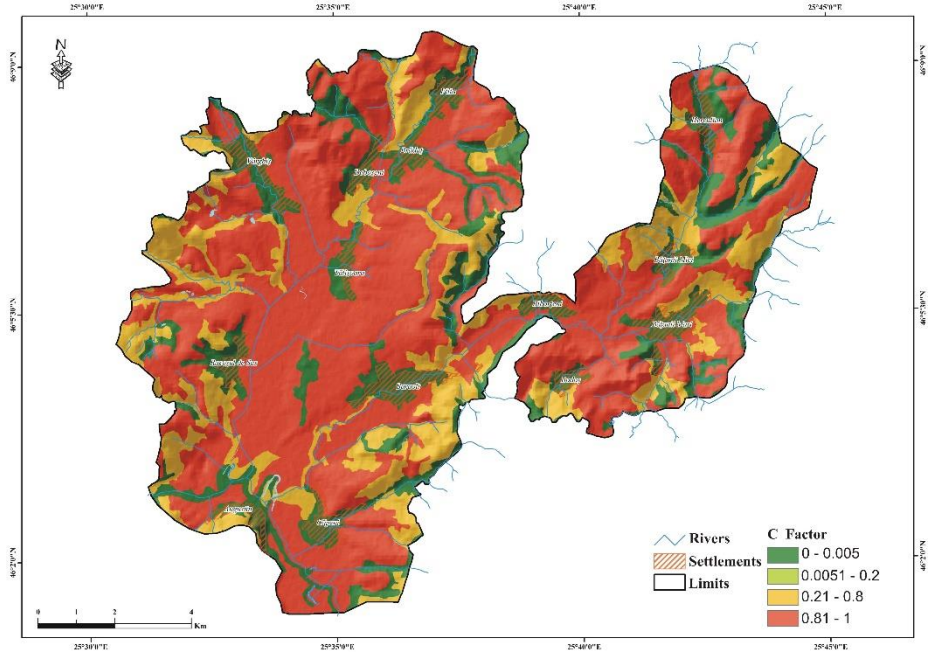
Soil erodibility factor *S* represents the tolerance of the soil or of the rock to rainfall or to wash-off done by the water run-off down the slope. The estimation of its value was based on *Indicator 186* used in *Soil study methodology* published by the Romanian Soil and Agrochemical Institute (ICPA) in 1987. To be able to use the values, we made the soil map of the Depression using the studies made by the Soil and Agrochemical Office Braşov. Using the Romanian System of Soil Taxonomy, we have seven soil classes (protisoil, cernisoil, luvisoil, cambisoil, andisoil, hidrisoil, antrisoil) and 16 soil types [4]. Taking into account all of these, we determined four erodability ranges: 0.7–0.8, 0.81–0.9, 0.91–1, and 1.01–1.1. The aluvosoils and technosoils have the highest coefficient, 1.01–1.1, from the meadows of the rivulets and of the River Olt and in the open pits. The lowest coefficient is for the faeoziom from the fluvial-lake terrace. The other soil types could be included in the range from 0.81 to 1 (*Map no. 2*).



Map 2. Susceptibility to soil loss according to the soil erodibility factor

Land-use factor *C* is a correction factor, calculated as a relation between soil erosion from a surface with certain vegetation and one without vegetation [4]. In the studied area, the values from 0 to 1 were grouped as (*Map no. 3*): areas with values between 0 and 0.005 – forest areas, hydrophilic vegetation from the meadow of the

River Olt and of the rivulets; areas with values between 0.005 and 0.2 – have a very small extent; areas with values between 0.2 and 0.8 – especially the hay lands; areas with values between 0.8 and 1 for grazing land and plough land.



Map 3. Susceptibility to soil loss according to land-use factor

Support practice factor *P* reflects the impact of support practices. As there is no integrated soil loss management in the area and considering that land-use factor includes the necessary data, we did not introduce it in the equation.

Using the G.I.S. platform Esri ArcGis, we made grids for each factor – as the above maps can illustrate –, superposed them, and used the equation.

3. Results and discussions

The values of the soil loss in the Baraolt Depression are between 0 and 2 t/ha/year.

The G.I.S. platform used allowed us to make a quantitative analysis of this soil loss model (*Map no. 4*) and offered valuable information about the phenomenon, usable in possible soil loss management works.

In the whole Depression, having a total surface of 144.4 km^2, the areas with a soil loss between 0 and 0.1 t/ha/year dominate with 87.5 km^2, which are 60.74%

from it (*fig. 1*). Here we can mention the meadows of the River Olt and of the other rivulets, the forested front of the volcanic plateau, the flat or slightly bulging heights, and the valley-free portions of the fluvial-lake terrace. This big proportion of areas with little soil loss is also due to the great weight of short slopes – less than 5 m (*Map 4*).

The second category is that of the areas with a soil loss between 0.1 and 0.5t/ha/year. It covers a total surface of 35.82 km^2, representing almost a quarter (24.87%) from the total area of the Depression. This category of land is spread in spots all over the surface of the Depression on low steep slopes used as hay lands and orchards.

The third category is that of the areas with a soil loss of 0.5 to 1 t/ha/year, covering a total surface of 12.16 km^2, amounting to 8% of the total area of the Depression. These areas have also spotted array.

The rates of soil loss between 1 and 1.5 t/ha/year and between 1.5 and 2 t/ha/year amount to 4.61 km^2 and 1.79km^2 (3.2% and 1.24%) respectively from the total surface of the Depression.

These areas are spread on the front of the fluvial-lake terrace, on the deforested slopes of the volcanic plateau and on the slopes of the following hills: Hotarului (620.7 m), Doboşeni Nord (641.6 m), Vârghiş Vest (751.3 m), Boldi (676 m), Vârful cu Păr (627 m), Pustnicului (566.9 m), Cinodului (641 m), Scândurii (641.6 m), Mestecănişul Mic (626.3 m), and Gaura Mică (623 m).

The highest rates of soil loss of over 2 t/ha/year cover just 2.14 km^2, namely 1.5%. These areas can be found on the upper part of the slopes of the hills previously mentioned, on the western, deforested front of the volcanic plateau near Herculian (plough and hay lands), the off-spring areas of some small creeks, and on the surfaces of the open pits.

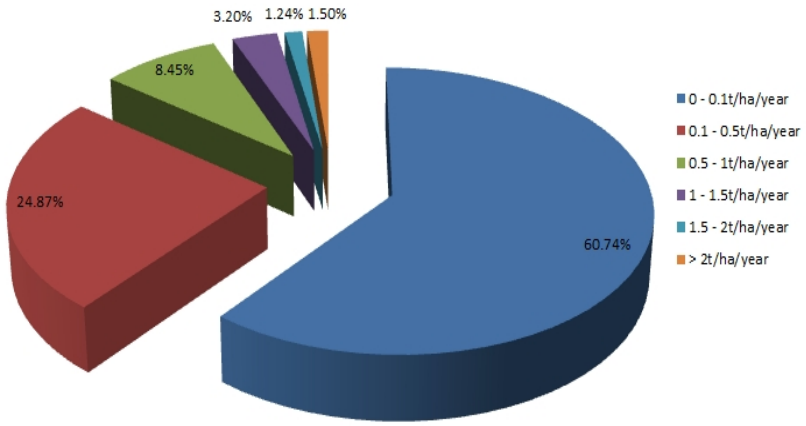
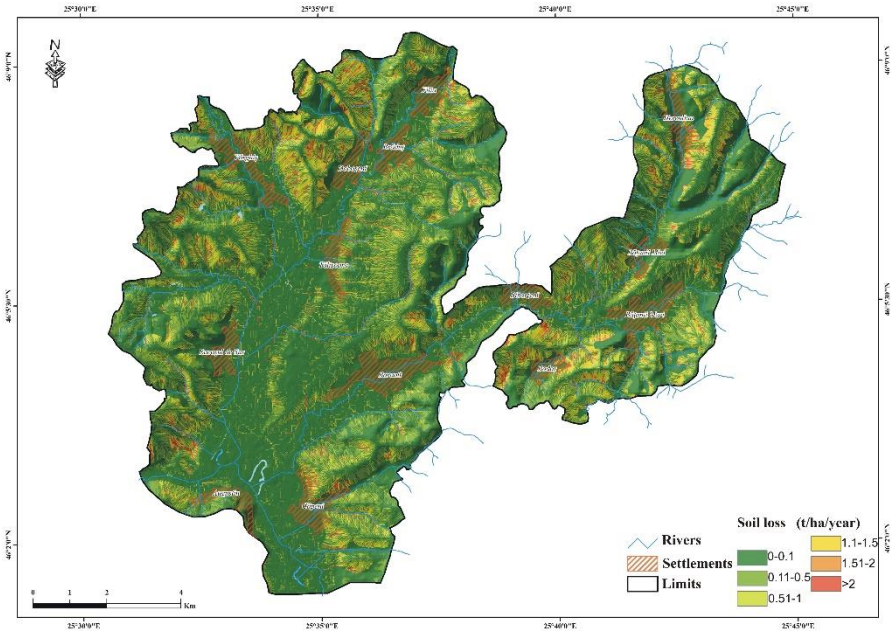


Figure 1. Areal distribution of the soil loss



Map 4. Soil loss map for the Baraolt Depression

4. Conclusions

The main factors to influence the quantity of soil loss in the Baraolt Depression are: 1. the land use (and we can notice the small values on forested areas and the values over 2 t/ha/year on the open pits); 2. the length and steepness of the slopes – small values on the meadows, on the terrace, and on the volcanic plateau and high values on the upper part of the slopes of the hills and on the front of the volcanic plateau, all of them with also high values of steepness.

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Awareness of the environmental implications of the unsustainable use of biomass energy sources among rural households in Jigawa State, Nigeria

Olusegun Martins ORIFAH,[1] Messiah Chijioke IJEOMA,[2]
Gloria Isi OMOKHUDU,[3] Gabriel T. AHUNGWA,[1]
Bashir Garba MUKTAR[1]

[1] Department of Agricultural Economics and Extension, Federal University Dutse, Dutse, Jigawa State, Nigeria. e-mail: martinsorifah@gmail.com

[2] Department of Agricultural Extension and Rural Development, University of Ibadan, Ibadan, Oyo State, Nigeria

[3] Department of Environmental Sciences and Toxicology Federal University Dutse, Jigawa State, Nigeria

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Abstract. Use of biomass energy is on the increase in rural areas of Nigeria, and its use poses serious environmental challenges. The study assessed the awareness of the environmental implications associated with the unsustainable use of biomass energy sources among rural households in Jigawa State, Nigeria. Multistage sampling procedure was used to select 120 respondents for the study using structured questionnaire. Collected data were analysed using descriptive (frequency counts, percentage, mean, and rank) and inferential statistics (chi-squared test). The result revealed that the majority of the respondents were male (94.2%), married (90.8%), and between 31 to 40 years, with a mean age of 39.8 years. Results further revealed that the majority of the respondents were farmers (56.7%), had Qur'anic education (71.7%), and earned a monthly income of ₦10,000–₦20,999 (52.5%), with a mean monthly income of ₦13,816.67. Use of fuel wood (100%) and charcoal (100%) were the dominant biomass energy sources used. Results at the level of awareness revealed that the majority of the respondents (80.8%) had low awareness of the environmental implications associated with the unsustainable use of biomass energy sources. The respondents' main source of information on the environmental implications associated with the unsustainable use of biomass energy sources were radio (64.17%) and extension agents (54.2%). The high cost of other alternatives, scarcity of refilling stations, scarcity of the alternatives, and lack of funds to purchase other alternatives are some of the major constraint bedevilling the use of non-solid energy sources. Level of education ($\chi^2 = 6.584$; $p < 0.1$) and

average monthly income ($\chi^2 = 8.277$; $p < 0.1$) were significantly related to awareness of the environmental implication of the unsustainable use of biomass energy. It is therefore recommended that people should be enlightened on the environmental implications associated with the unsustainable use of biomass energy sources. Furthermore, policies favouring a switch of energy source should be considered.

Keywords: awareness, rural households, environmental implications, biomass energy, clean energy, Jigawa State

1. Introduction

Energy is essential for our very existence, with its use in diverse ways, such as cooking, heating, lighting, electrical appliances, and building insulations. Nigeria is blessed with rich and diverse renewable and non-renewable energy resources such as crude oil, natural gas, coal, solar energy, wind energy, biomass, biogas, etc. [1]. However, despite the abundance of various energy sources in the country, the issue of electricity and scarcity of alternate energy sources for households' utilization still looms, with millions of her inhabitants still lacking access to clean and affordable energy source. This development has forced many into seeking alternative energy sources. Bamiro and Ogunjobi (2015) [2] noted that household energy consumption accounts for 15–25% of the total primary energy use in developing countries. Gujba et al. (2015) [3] opined that the household cooking sector consumes the most energy in Nigeria, it accounts for about 80% of the total energy and 90% is from biomass energy alone. The use of biomass energy for cooking has led to environmental pollution and has increased greenhouse gases in the atmosphere due to the emission of CO2 [4].

Biomass energy use involves the use of fuel wood, plant residue, animal dung, coal, etc. It is the major cooking energy source amongst rural household dwellers in Nigeria [2]. Biomass energy consumption constitutes about 90% of the rural household energy consumption in Nigeria [3]. Biomass is a renewable energy resource, but its unsustainable harvest and use (particularly trees) have grave consequences for the environment, trees are constantly felled without replacement, thereby contributing to the reduction of the carbon sink available to absorb the atmospheric carbon, which is a major component of greenhouse gasses [5]. It also leads to desertification, reduction in soil nutrient and soil microorganisms due to constant cultivation of the soil and the endangerment of some wildlife species whose place of natural habitat is destroyed [6, 7]. Bamiro and Ogunjobi (2015) [2] noted that the production and consumption of energy generally have environmental implications. Elijah (2012) [8] reported that the major cooking energy source in Nigeria is predominantly biomass with charcoal and wood biomass accounting for 31% and 50% respectively. Sambo (2009) [9] noted that Nigeria consumes more

than 50 million metric tonnes of fuel wood annually, and this leads to the constant felling of forest trees, thereby exposing the environment to harsh weather.

Use of biomass has been reported to emit toxic pollutants such as carbon monoxide, respirable particles, oxides of nitrogen and sulphur, which are dangerous to the environment and health [10]. Furthermore, desertification and forest degradation have been linked to the constant harvesting of wood for firewood or charcoal production [11]. There are various environmental implications associated with the use of biomass energy sources, but then statistical evidence shows that the usage is still on the high side and persists across the different geopolitical categorizations of Nigeria. The National Bureau of Statistics (NBS) (2012) [12] reported that in 2010 95% of the energy sources used for cooking in households in Jigawa State was fuel wood. Jigawa State Government (JSG) and Education Sector Support Programme in Nigeria (ESSPIN) (2014) also reported that both natural and human factors were responsible for forest cover depletion and thereby making the northern part of the State highly vulnerable to desert encroachment [13]. Furthermore, IEA (2007) reported that there will be a marked increase to the number of people relying on biomass energy source from 2.6 billion in 2015 to 2.7 billion by 2030 if mitigating polices are not explored [14]. Given the foregoing, it becomes necessary to ask if the rural households in Jigawa State have understanding of the environmental implications of the unsustainable use of biomass or not. Do they have access to information on the environmental implications associated with the unsustainable use of biomass? Other germane questions that readily come to mind include what the compelling drives encouraging the persistent use of this form of energy among the people in the area are. It is upon these premises that this study assessed the awareness of the environmental implications of the unsustainable use of biomass energy sources among rural households in Jigawa State, Nigeria. Specifically, the study:

i. described selected personal characteristics of the respondents,
ii. identified the types of biomass energy used by the respondents,
iii. assessed the awareness of the environmental implications of the use of biomass fuel for cooking by the respondents,
iv. identified respondents' sources of information on the environmental implications associated with the use of biomass, and
v. investigated respondents' constraints to the use of non-solid energy source.

2. Methodology

The population for the study consisted of rural households in the northern fringes of Jigawa State, Nigeria. Jigawa State is predominantly an agrarian state with over 80% of the population involved in Agriculture [15]. The State is situated within

the Sudan savannah vegetation zone; however, there are traces of Guinea savannah in the southern part of the State. Its total forest cover is about 5% due to low-rainfall characteristics and deforestation primarily due to the use of wood for cooking, thereby making the northern part of the State highly vulnerable to desert encroachment (Jigawa State Government, 2017) [15]. A multi-stage sampling procedure was adopted for this study. The first stage involved the purposive selection of all the nine identified Local Government Areas in the northern fringes of the State. The northern fringes represent the area of intense deforestation both by natural and human activity. The next stage was the use of simple random sampling to select three (3) Local Government Area (Biriniwa, Sule Tankarkar and Babura) out of the nine Local Government Areas identified. Subsequently, two communities from each Local Government Area (Birniwa: Kukawa and Yusufari. Sule-Tankarkar: Jeke and Sule Tankarkar. Babura: Kanya Babba and Dorawa) were randomly selected to give a total of six (6) communities. The third stage involved the use of snowball sampling to generate a list of all households that use biomass energy sources. From the list generated, a total of 120 households were randomly selected proportionately and used for the study. Due to the role played by the heads of the households in decision-making at home, the heads of the households were purposively selected for the study. Structured questionnaire was used to obtain data on the respondents' socioeconomic characteristics, the type of biomass energy used, awareness of the environmental implications of the use of biomass fuel for cooking, sources of information on the environmental implication of the use of biomass, and constraints to the use of non-solid energy source. The obtained data were analysed using descriptive (frequency count, percentages, means, and ranks) and inferential statistics (chi-square).

3. Results and discussions

3.1. Respondents' personal characteristics

The results in *Table 1* show that the majority of the respondents are male (94.2%) and between 31 and 40 years (50%), with a mean age of 39.8 years. This implies that the majority of the respondents are males, in their middle and active age. This suggests that we have more male-headed households in Jigawa State, Nigeria, than female-headed households.

The results *in Table 1* further reveal that the majority of the respondents' have only Qur'anic education (71.7%), are married (90.8%), and have a household size between 6 and 10 persons (53.3%). This result supports the assertion of Antoninis (2014) [16] that the education pattern in Northern Nigeria is traditionally dominated by religious education, with Islam being the major religion, and that, instead of

improving the people's life, this has caused a decline in circular education in the area and resulted in so many of them being illiterate.

The results on occupation and average monthly income showed that a little above half of the respondents had farming as their occupation (56.7%) and more than half (52.5%) earned between ₦10,000 and ₦20,999 on a monthly basis with a mean income of ₦13,816.67. This implies that the respondents are small-scale farmers and may not have the wherewithal to adopt the use of cleaner energy sources.

Table 1. Selected personal characteristics of respondents

Variables	Frequency	Percentage	Mean
Age			
≤ 20	2	1.60	39.8
21–30	15	12.5	
31–40	60	50.0	
41–50	31	25.8	
51 and above	12	10	
Sex			
Female	7	5.8	
Male	113	94.2	
Religion			
Muslim	120	100	
Level of education			
Qur'anic	86	71.7	
Primary	19	15.8	
Secondary	13	10.8	
Tertiary	2	1.7	
Marital status			
Single	1	0.8	
Married	109	90.8	
Divorce	6	5.0	
Widow	4	3.3	
Household size			
1–5	26	21.7	9
6–10	64	53.3	
11–15	20	16.7	
16–20	10	8.3	
Occupation			
Civil servant	18	15.0	
Teaching	13	10.8	
Farming	68	56.7	
Trading	14	11.7	
Artisan	7	5.8	

Average monthly income (₦)			
≤ 9,999	41	34.2	13,816.67
10,000–20,999	63	52.5	
21,000–30,999	5	4.2	
31,000– 0,999	8	6.7	
41,000–50,999	3	2.5	

Source: Survey results, 2017

3.2. Types of biomass energy source used by respondents

Results in Table 2 show the types of biomass energy sources used by the respondents. The results indicate that all the respondents use firewood (100%) and charcoal (100%), with little above half of them using plant residue (53.3%). The result of this study is in consonance with the positions of Kayode et al. (2015) and Bamiro and Ogunjobi (2015) [17, 2], who separately found high usage of fuel wood, charcoal, and plant residue as energy source amongst rural households in Nigeria. These could be attributed to the high cost of cleaner energy sources like LPG, the family income, preferences, and habits [18, 2]. Adeyemi and Ibe (2014) [19] also found that there was a high use of firewood compared to other energy sources amongst households in Jigawa State, Nigeria. This trend, according to Zaku et al. (2013) [20], will still continue and may worsen if nothing is done to revive the economic situation in the country and as long as the energy crisis still looms in the country. Hence, there is need to revitalize the Nigerian energy sector and make it easily assessable for use by rural households in Nigeria.

Table 2. Type of biomass energy source used by respondents

Biomass energy source	Frequency	Percentage
Fuel wood	120	100
Charcoal	120	100
Animal dung	17	14.2
Saw dust	10	8.3
Coal	0	0.0
Plant residue	64	53.3

*Multiple responses Source: survey results, 2017

3.3. Respondents' awareness of the environmental implications of the unsustainable use of biomass fuel for cooking

Results in *Table 3* revealed that the majority of the respondents (93.3%) are aware that the unsustainable use of biomass exposes the soil to erosion and that desertification is enhanced by the unsustainable harvest of trees for cooking (76.7%). The respondents further indicated that they were not aware that rainfall and temperature variability were environmental phenomena that are also influenced by the unsustainable use of biomass (95.8%), that environmental air is affected negatively by the unsustainable use of biomass (92.5%), and that soil microbes that enhance soil formation are destroyed by unsustainable use of biomass (93.3%). The finding implies that the majority of the respondents are not aware of the environmental implications associated with the unsustainable use of biomass fuel for cooking. These findings could be attributed to the low level of educational attainment amongst the respondents. The results of the categorization of the levels of awareness in *Table 4* show that 80.8% of the respondents have low awareness of the environmental implications associated with the unsustainable use of biomass fuel, while 19.2% of the respondents have high awareness of the environmental implications. This implies that the majority of the respondents are not fully aware of the environmental implications of unsustainable use of biomass fuel for cooking and thus suggest that a lot needs to be done to change people's perspectives. In a related study (Food versus Biomass Fuel: Socioeconomic and Environmental Impacts in the United States, Brazil, India, and Kenya), Pimentel et al. (1988) [21] argued that the removal of biomass from land for energy production increases the effects of wind and water degradation, flooding, and nutrient loss through topsoil erosion, it also affects wildlife communities by disrupting their natural ecosystems, and threatens the health of some human populations. WHO (2017) [22] opined that there are high emissions of carbon monoxides, hydrocarbon, and particulate matters from the combustion of fuel wood, roots, agricultural residue, and animal dung. These emissions are culpable for global warming. Some of the attendant effects of global warming are all over the literature, and these include flood, heat waves, unpredictable rainfall and temperature patterns, drought, desertification, and crop failure, to mention but a few. With a low awareness of the environmental implications of the unsustainable use of biomass and the increasing use of biomass energy in an unsustainable manner in Nigeria and other countries like South Africa [23] and the world at large [24], it can be inferred that danger looms on the face of the earth and thus calls for concerted efforts from all stakeholders and policy makers in figuring out ways to change the trend and correct the anomaly.

Table 3. Awareness of the environmental implications of unsustainable use of biomass fuel for cooking

Variables	Aware	Not aware
Unsustainable use of biomass exposes the soil to erosion.	112 (93.3)	8 (6.7)
Desertification is enhanced by unsustainable harvest of trees for cooking.	92 (76.7)	28 (23.3)
Soil nutrients are depleted faster when biomass are harvested on an unsustainable basis.	42 (35.0)	78 (65.0)
Environmental air is affected negatively by unsustainable use of biomass.	9 (7.5)	111 (92.5)
Rainfall and temperature variability are environmental phenomena that are also influenced by unsustainable use of biomass.	5 (4.2)	115 (95.8)
Soil microbes that enhance soil formation are destroyed by unsustainable use of biomass.	8 (6.7)	112 (93.3)
Forest wildlife becomes endangered when biomass is harvested on an unsustainable basis.	39 (32.5)	81 (67.5)
Biodiversity is lost.	21 (17.5)	99 (82.5)

Source: survey results, 2017

Table 4. The categorization of respondents' awareness of the environmental implications of the unsustainable use of biomass fuel for cooking

Awareness of environmental implications	Scores	Frequency	Percentage	Mean
High	12–13	23	19.2	10.75 ± 0.92
Low	9–11	97	80.8	

Source: survey results, 2017

3.4. Sources of information on environmental implication on the use of biomass energy

The results in *Table 5* indicate respondents' source(s) of information on environmental implications of the use of biomass energy sources. The results revealed that the majority of the respondents (64.17% and 54.2%) received the information on the environmental implication of the use of biomass energy from the radio and extension agents respectively. However, the majority of the respondents indicated that they did not get information on the environmental implications of the use of biomass from religious houses (100%), non-governmental organizations

(NGO) (99.2%), newspapers (98.33%), cooperative societies (94.2%), and television channels (86.67%). This implies that religious houses, NGOs, newspapers, and cooperative societies do not educate the people on the environmental implications associated with the use of biomass energy source but are only concerned with the mandates of which they are formed.

Table 5. Respondents' sources of information

Information Sources	**Yes**	**No**
Radio	77 (64.17)	43 (35.83)
Television	16 (13.33)	104 (86.67)
Newspapers	2 (1.67)	118 (98.33)
Extension agents	65 (54.2)	55 (45.8)
Cooperative society	7 (5.8)	113 (94.2)
Non-Governmental Organizations (NGO)	1 (0.8)	119 (99.2)
Religious bodies	0 (0.0)	120 (100.0)
Friends/neighbours	30 (25.0)	90 (75.0)

*Multiple responses Source: survey results, 2017

3.5 Constraints of using non-solid energy sources for cooking

Table 6 shows the factors that restrain respondents from the use of non-solid energy sources. The results revealed that the high cost of other alternatives (91.7%), the scarcity of refilling stations (85.0%), the scarcity of the alternatives (80.0%), and lack of funds to purchase other alternatives (60.0%) are some of the major constraints around the use of non-solid energy sources amongst respondents. These results are in agreement with the findings of Hammeed et al. (2015) [18], who separately found lack of funds to purchase alternatives, scarcity of plants/refilling stations, and high cost of alternatives as the major constraints hindering rural households from choosing alternative and cleaner energy sources. These findings indicate that poverty is still prevalent in the area and corroborates the findings of Agbaeze and Onwuka (2015) [25], who noted that the majority of rural households are poor and live below the poverty line in Nigeria.

Table 6. Constraints of using non-solid energy source amongst respondents

Variables	Severe	Mild	Not a constraint	Remarks
High cost of other options	110 (91.7)	10 (8.3)	0 (0.0)	Severe
Lack of funds to purchase other options	72 (60.0)	38 (31.7)	10 (8.3)	Severe
Scarcity of the alternative	96 (80.0)	20 (16.7)	4 (3.3)	Severe
High risk involved in the usage of other materials	9 (7.5)	40 (33.3)	71 (59.2)	Not a constraint
Scarcity of refilling stations	102 (85.0)	17 (14.2)	1 (0.8)	Severe
Distance to refilling/selling points	57 (47.5)	30 (25.0)	33 (27.5)	Severe
Lack of technical know-how on the use of other materials	0 (0.0)	6 (5.0)	114 (95.0)	Not a constraint
Lack of preference for alternatives	0 (0.0)	2 (1.7)	118 (98.3)	Not a constraint

Source: survey results, 2017

3.6. Test of the relationship between respondents' socioeconomic characteristics and level of awareness of the environmental implications of the unsustainable use of biomass fuel

The results in *Table 7* show the summary of the chi-squared analysis of the relationship between selected socioeconomic characteristics of respondents and awareness of the environmental implications of the unsustainable use of biomass energy sources. The results revealed that level of education ($\chi^2 = 6.584$; $p = 0.086$) and average monthly income ($\chi^2 = 8.277$; $p = 0.082$) were significant to respondents' awareness of the environmental implications of the unsustainable use of biomass energy sources. However, their age ($\chi^2 = 5.549$; $p = 0.235$), marital status ($\chi^2 = 3.681$; $p = 0.298$), household size ($\chi^2 = 1.783$; $p = 0.619$), and occupation ($\chi^2 = 3.633$; $p = 0.458$) were not significant to respondents' awareness of the environmental implications on the unsustainable use of biomass energy sources. This implies that respondents' awareness of the environmental implications on the unsustainable use of biomass is a function of their level of education and income. This gives credence to the findings of Zaku et al. (2013) [20], who established that the use of biomass energy sources was more predominant with the poor and the less educated people; it also justifies the position of Uhunamure et al. (2017) [23], who noted that when there is an increase in income, people move away from the use of biomass energy to more cleaner energy sources such as LPG and electricity. This movement of people with higher education and income is deemed by and large to be associated with their

awareness of the environmental and health implications associated with the use of biomass energy. This assertion corroborates the statement of Hammed et al. (2016) [18], who posited that rural households with high income and a high level of education tend to opt rather for environmentally friendly cooking energy sources, such as LPG, than biomass energy sources. The findings here suggest that certain socioeconomic attributes are key in deciding the energy switch behaviour of rural people, but this in itself is not a sufficient condition as issues bordering around access, availability, preferences, etc. are also germane to this study. It is therefore important for policy-supporting decisions to consider an approach that is holistic.

Table 7. Chi-squared analysis showing the relationship between respondents' socio-economic characteristics and their level of awareness of the environmental implications on the unsustainable use of biomass fuel for cooking

Variables	**χ^2-value**	**Df**	**p-value**
Age	5.549	4	0.235
Level of education	6.584*	3	0.086
Marital status	3.681	3	0.298
Household size	1.783	3	0.619
Occupation	3.633	4	0.458
Average monthly income	8.277*	4	0.082

χ^2 = chi-squared coefficient, df = degree of freedom, p-value = probability level of significance, *= significant at $p \leq 0.1$

4. Conclusion and recommendations

The findings revealed that the majority of the respondents are male, farmers, and married. Fuel wood, charcoal, and animal dung are the major biomass energy sources used by the respondents. The results further showed that the majority of the respondents are not aware of the environmental implications associated with the use of biomass energy sources for cooking. However, they are restrained from using cleaner alternative energy sources due to lack of funds, high costs of alternative energy sources, scarcity of cleaner alternative energy sources in their area, and the scarcity of refilling stations. The results of the test of the relationship between respondents selected based on socioeconomic characteristics and their level of awareness of the environmental implications on the use of biomass energy revealed that only the level of education and income were significantly related to their level of awareness of the environmental implications of the use of biomass energy. From the findings of this study, it is therefore recommended that people should be enlightened on the environmental implications associated with the use of biomass energy sources; NGOs, religious institutions, etc. should as a matter of urgency start

widespread campaigns to educate people on the environmental implications of using biomass energy sources in an unsustainable manner. Rural households should be encouraged to take to livelihood diversification through expositions and trainings to increase their income base, and the government should make efforts to bring development to the grassroots and have private partners engaged in the establishment of skid plants.

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Disease incidence, identification, and monthly fluctuations in the population density of root-knot nematodes *Meloidogyne javanica* on cucumber plants in Semel District, Duhok, Kurdistan Region, Iraq

Sulaiman Naif AMI, Shireen GHAEIB, Ali SHINGALY

Department of Plant Protection, College of Agriculture, University of Duhok,
Kurdistan Region – Iraq
e-mail: sulaiman.ami@uod.ac (corresponding author), ghalib@univsul.edu.iq, ali.shingaly@uod.ac

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Abstract. A survey was performed in four locations of Semel District – as follows: Sartenk, Qesir yazdin, Sharia, and Grshin (Bawerde) – by selecting 4 greenhouses planted with cucumber plants (*Cucumis sativus* L.) on each location, during both growing seasons (spring and autumn) of the year 2015. The results showed that the incidence of root-knot disease increased to its maximum level (37.48%) in the autumn season and then decreased to its minimum level (34.67%) in the spring season. According to the surveyed locations, the highest disease incidence (73.05%) was recorded in Sartenk location and the lowest (13.54%) in Sharia location. Results of the interaction between the locations and seasons revealed that the highest disease incidence (80.5%) appeared in Sartenk location during the autumn growing season followed by 65.60% in the same location during the spring growing season, whereas the lowest percentage was reported in Sharia during the spring season (3.47%). Depending on the perineal patterns for species identification of *Meloidogyne* spp. on cucumber plants, results showed the presence of *Meloidogyne javanica* in all surveyed locations. Generally, in one of the greenhouses of Sartenk location, the population density of *M. javanica* reached its maximum level (1,762 nematodes/200 gm soil) in September 2015, while the minimum level (337.5 nematodes/200 gm soil) was recorded in May the same year.

Keywords: *Meloidogyne javanica*, disease incidence, identification, population density, cucumber

1. Introduction

Cucumber (*Cucumis sativus* L.) is considered as one of the essential vegetables and one of the most common individuals of the family Cucurbitaceae [20], and it grows quickly, within a very short time from the date of planting as compared to other crops [39]. Cucumber is affected by nematodes, fungal, viral, bacterial, and six genera of plant-parasitic nematodes as follows: *Meloidogyne*, *Helicotylenchus*, *Pratylenchus*, *Scutellonema*, *Rotylenchulus*, and *Aphelenchoides* [15]. The *Meloidogyne* genus has the ability to affect 5,500 species of plants [5]. The *Meloidogyne* species are economically very important soil-borne pests that cause diseases to the root systems of many crops [33].

Generally, the symptoms of plants caused by root-knot nematodes can manifest above and under the ground. The symptoms above the ground may include spare growth, patchiness, chlorosis, stunting, defoliation, loss of yield, and wilting [34]. Underground symptoms consist of gall formation on roots, and the infection of plants tends to have few secondary roots. The number of egg masses and galls on the roots differs by the population density of nematodes in the soil, environmental factors, and host susceptibility [28]. At the end of 2012, nearly 100 nominal species of *Meloidogyne* were identified [25]. Thus, this study aims to determine root-knot disease incidences and carry out species identification of root-knot nematodes *Meloidogyne* on cucumber plants, while it also aims to calculate the monthly fluctuations in nematode population density during the growing season of cucumber plants in Semel District, Duhok, Kurdistn Region, Iraq.

2. Materials and methods

A. Survey of greenhouses planted with cucumber for the detection of root-knot disease

Survey was performed by selecting 4 greenhouses where cucumber was planted in 4 locations within Semel District as follows: Sertank, Grshin (Bawerdie), Sharia, and Qesiryazdin, during 2015 in both spring (May, June, and July) and autumn (August, September, and October). Roots and soil samples were taken using a systemic pattern (zigzag method), as described by Coyne et al. [11], where soil from the rhizosphere area and root samples of infected cucumber plants were collected at a depth of 20–30 cm from each greenhouse, taking into account that the samples represented an area of each greenhouse. Samples were placed separately in polyethylene bags, moist, with little amounts of distilled water, and for each sample the sampling date, planting date, and location name were recorded. The samples kept in cool boxes (insulated container) with pieces of ice and brought

to the laboratory where preserved at 4 ºC for a period not exceeding 3 days. Each house was considered as a single unit and sampling sites deposited on alternations of planting lines to assess disease incidence depending on the presence of galls on the examined roots and according to the following equation used by Kayani et al. [18]:

$$\% \text{ of disease incidence} = \frac{\text{No of infected plants}}{\text{Total no. of examined plants}} \times 100$$

This experiment consists of 8 treatments (4 locations × 2 lugs) with 4 replications and was carried out as factorial experiment in Completely Randomized Design (CRD). Data were analysed using SAS program, and the means of disease incidence in the surveyed locations were compared based on Duncan's multiple range test, $p \leq 0.05$ [32].

B. Identification of root-knot nematodes Meloidogyne spp. by perineal pattern

Perineal patterns of *Meloidogyne* species were prepared according to a method mentioned by Hussain et al. [14], through which perineal patterns of 10 females were prepared for each infected cucumber in the greenhouses. The perineal patterns were compared with standard diagrams, and then *Meloidogyne* species was identified.

C. Monthly fluctuations in the population density of root-knot nematode M. javanica in a greenhouse located in Sertank village, planted with cucumber plants

One of the cultivated greenhouses in the Sertank village location was selected to study the fluctuation of nematode population density during 2015 for spring lug (May, June, and July) and autumn lug (August, September, and October). Soil samples were gathered as mentioned previously, placed on a piece of polyethylene in laboratory, and mixed well by hand for homogeneity. Four random samples (200 gm/sample) were taken for nematode extraction using tray method as used by Kago et al. [16]. The population density of *M. javanica* was calculated using a method described by Van Benzooijen [36], with some modifications. The number of J2s (second-stage juveniles) was counted in the suspension of each sample, which was determined to a particular volume in each beaker, the nematode suspension was carefully mixed by shaking it with a sterilized glass rod for homogeneity, and 1 ml of suspension was directly transferred to a counting dish with the help of a sterilized glass pipette. Nematodes were counted under stereomicroscope with 5 replications for each sample.

This experiment consists of 6 treatments (6 months) with 4 replications performed in CRD. Data were analysed as mentioned previously to compare the means of nematode population density/month.

D. Soil analysis for some physical and chemical properties

i. **Soil texture:** Soil texture was determined by the hydrometer method according to Bowles [8] to estimate soil contents of clay, silt, and sand.
ii. **Soil pH:** It was determined by pH-meter model Hans Herbert Mennerich (geotechnical), Hanover, as described by Van Reeuwijk [37].
iii. **Electrical conductivity (E.C.):** The electrical conductivity was estimated by using E.C.-meter, model D8120, and adjusted to 25 ºC, as stated by Van Reeuwijk [37].
iv. **Organic matter:** Oxidizable organic matter was determined by the Walkley and Black, wet dichromate oxidation procedure, as mentioned by Nelson and Sommers [23].
v. **Total Nitrogen:** Total nitrogen in soil was estimated according to the Kjeldhal method, as described by Rowell [31], using concentrated H2SO4 and H2O2 with heating for soil digestion.

3. Results and discussion

3.1 Survey of greenhouses planted by cucumber plants in Semel District to detect the presence of root-knot disease

The symptoms associated with root-knot nematode were clear in four surveyed locations, where stunting, wilting, chlorosis, loss of yield, death of plant, patchiness, and formation of galls on roots were detected (*Fig. 1*).

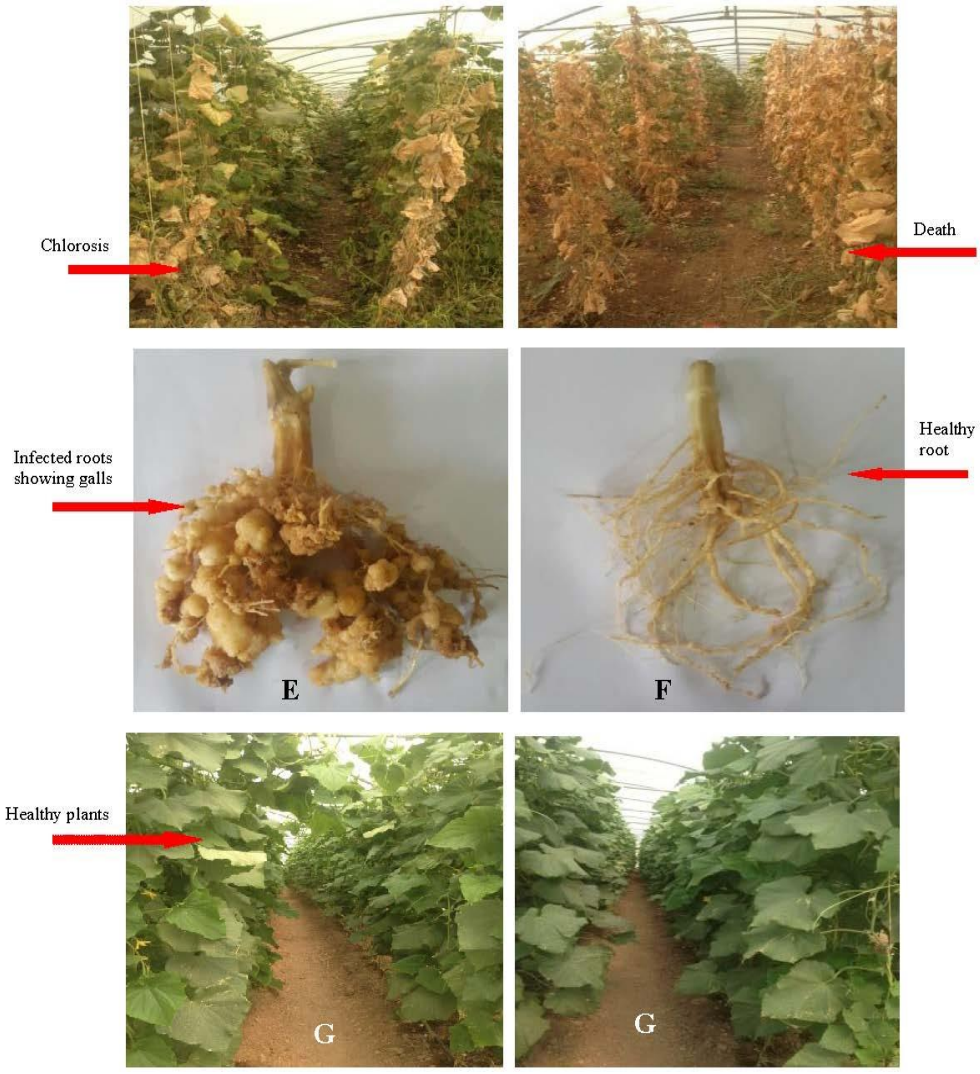

Figure 1. Patchiness (A), stunting (B), chlorosis (C), death (D), and root galling (E) as symptoms of root-knot nematode *M. javanica* compared to healthy plants (F and G) in the surveyed locations

3.2 Disease incidence of root-knot disease on cucumber plants caused by M. javanica

Results in *Fig. 2* showed that the highest disease incidence (37.48%) was recorded in the autumn season, while the lowest one (34.67%) in the spring season though the difference was not significant, as revealed by the results of the statistical analysis. Regarding the surveyed locations, disease incidence reached its maximum level (73.05%) in Sartenk with a significant difference from the disease incidence rates in the other locations, and then it decreased to its minimum level (13.54%) in Sharia location, which did not differ significantly from the disease incidence rate in Qesir yazdin (*Fig. 3*). On the other hand, the interaction between seasons and locations (*Fig. 4*) was significant in its effect on disease incidence, and in general the highest disease incidence rate (80.5%) was reported in Sartenk location, in the autumn season, which did not differ significantly from the disease incidence in the same location in the spring season; however, the lowest disease incidence (3.47%) was found in Sharia location in the spring season, without significant differences from the disease incidence of Qesir yazdin in both seasons and from that of Grshin in the spring season.

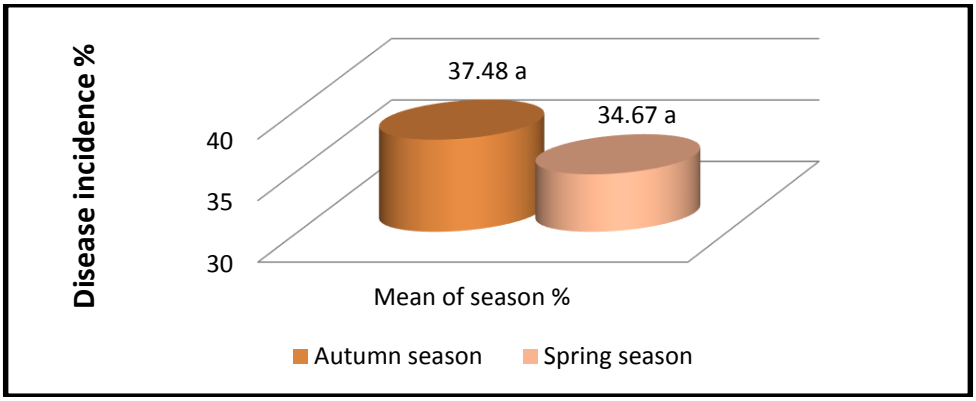

Figure 2. Disease incidence of root-knot in both growing seasons: spring and autumn. Means do not differ significantly based on Duncan's Multiple Range test ($P \leq 0.05$). Each number is a mean of 16 values (4 locations × 4 replications).

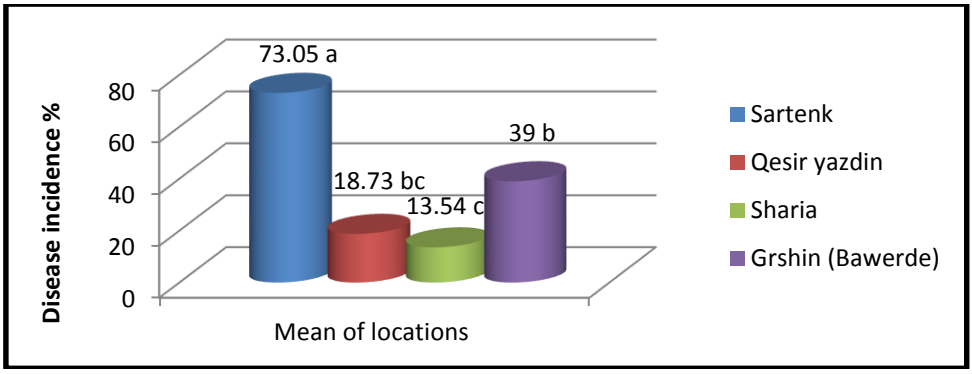

Figure 3. Disease incidence as affected by different locations.
Means followed by different letter(s) differ significantly based on Duncan's Multiple Range test ($P \leq 0.05$).
Each number is a mean of 8 values (2 seasons × 4 replications).

The physical and chemical properties of the surveyed soil showed that the soil of most tested greenhouses was sandy clay loam, the maximum percentage of sand (73.92%) was found in Sartenk and the minimum percentage (35.72%) in Qesir yazdin. The maximum percentage of organic matter (5.1%) was recorded in the soil of Qesir yazdin and the minimum (1.67%) in the soil of Sartenk.

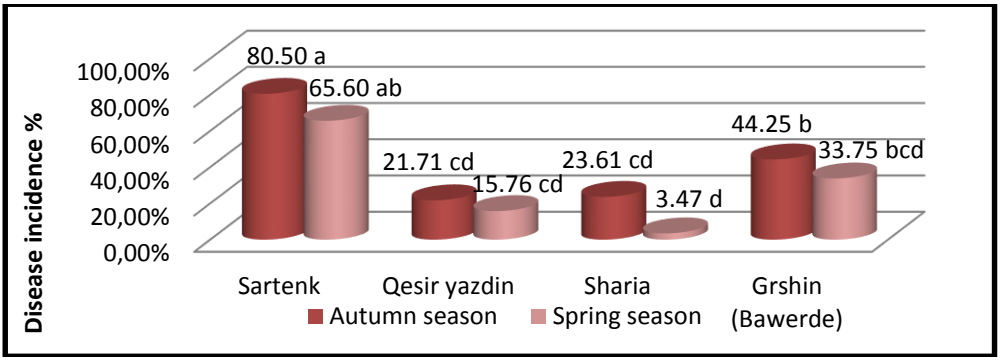

Figure 4. Disease incidence during both seasons (spring and autumn) in 2015 in the surveyed locations.
Means followed by different letter(s) differ significantly based on Duncan's Multiple Range test ($P \leq 0.05$).
Each value is a mean of 4 replications.

Results of pH were almost similar in all locations, ranging from 7.2 to 8. The E.C. increased in the soil of Sharia (6.31) and then declined in the soil of the other locations, the minimum (0.61) being reported in the soil of Sartenk. The C/N ratio was found to be high (14.7) in Grshin followed by Qesir yazdin (13.2), and a low value (3.2) was recorded in the Sartenk soil (*Table 1*).

The increase in the disease incidence of root-knot nematode is due to a number of reasons such as appropriate temperature for nematode activity, including egg hatching and juvenile development, which is consistent with Madulu and Trudgill [21], Trudgill [35], Park et al. [27], and Ismail et al. [15], as well as planting of susceptible cucumber varieties during the growing season, as found by Agrios [2], Chaudhary et al. [10], and Kayani et al. [18]. In addition to that, the soil may be planted with the same suitable plant hosts during the period preceding the autumn season and the remaining of infected plant debris roots in the soil.

Table 1. Physical and chemical analysis of the soil in the surveyed locations

Locations	**Green houses**	Clay %	Silt %	Sand %	Soil texture	Organic matter %	pH	E.c. dSm^{-1}	C/N ratio
Grshin	1	29.77	15.44	54.79	Sandy clay loam	3.41	7.26	6.26	5.5
	2	25.01	19.88	55.11	Sandy clay loam	2.52	7.3	5.35	9.1
	3	28.27	23.64	48.09	Sandy clay loam	2.36	7.63	5.25	6.1
	4	22.03	27.16	50.81	Sandy clay loam	2.65	7.76	1.46	14.7
Qesir yazdin	1	15.98	28.08	55.99	Sandy loam	5.10	7.35	5.60	13.2
	2	22.56	36.19	41.25	Loam	1.74	7.52	3.41	6.01
	3	25.35	38.49	35.72	Loam	2.86	7.14	5.10	7.4
	4	20.15	17.60	62.28	Sandy clay loam	3.13	7.45	4.82	6.5
Sharia	1	22.08	31.90	40.02	Loam	3.21	7.35	6.31	7.07
	2	26.08	16.23	57.70	Sandy clay loam	4.47	7.65	4.9	13.03
	3	25.43	28.51	46.07	Sandy clay loam	3.55	7.46	5.12	8.1
	4	26.21	35.26	38.52	Loam	4.26	7.41	5.35	6.8
Sertank	1	12.55	13.53	73.92	Sandy loam	1.67	7.43	1.43	3.4
	2	27.54	22.86	49.60	Clay loam	1.88	7.70	0.62	3.2
	3	16.77	31.51	51.72	Loam	3.48	7.63	0.61	7.2
	4	18.91	29.17	51.92	Loam	3.07	8.00	1.47	5.2

E.c. = electric conductivity, dSm^{-1} = decimals, C= carbon, N = nitrogen

However, the decrease of disease incidence in the spring season largely attributed to low temperature in the winter in addition to the absence of the host, which led to the death of numerous nematode eggs and J2s, which was confirmed by Ami [6] and Ami and Al-Sabie [7]. The variability of disease incidence among surveyed locations can be traced back to some chemical and physical properties of the soil. Thus, the highest disease incidence appeared in the Sartenk greenhouse, where the soil contains a high percentage of sand and a low percentage of clay particles, where the pores of such soil are suitable for nematode movement [13], [19] toward the roots of its hosts [12]; moreover, the low value of electrical conductivity (E.C.) in the soil of Sartenk compared to the soil of other locations played a role in nematode activity [17]. Therefore, the nematode population increased in sandy soil compared to clay soil [38], [30], while the presence of clay in low percentage in the soil also attracts nematode juveniles from long distances towards the roots of plants through adsorption of root exudates on their surface. This view is consistent with what has been reported by Prot and Van Gundyl [29], which means that soil texture has influence on the movement of nematodes toward the plant roots and then on their reproduction [22], [14].

Furthermore, increasing organic matter percentage in the soil reduced nematode population [24], whereas in this study the absence of the effect of organic matter in showing differences in disease incidence between locations may be due to the convergence of its value in the majority of soils in the study locations. Also, the impact of pH on disease incidence is almost identical in the soil of all locations due to the convergence of its values, where the pH of soil was within the appropriate range for nematode survival and reproduction [26]. The ratio of C/N was less than 20 (have enough nitrogen), which caused a decrease in the number of nematodes as reported by Agbenin [1] and Agu [3]. Therefore, in our study, the role of C/N ratio may be the same because its value was less than 20 in all studied locations. The decrease in the disease incidence in Sharia and Qesir yazdin may also be due to the application of some methods for nematode control such as the use of nematicides, animal manure, planting of garlic among cucumber plants, and fallowing.

3.3 Identification of root-knot nematodes by perineal pattern

Results of recognition of root-knot nematodes depending on the morphological characters of perineal patterns of mature females extracted from infected roots of cucumber plants in 4 surveyed locations, including Sartenk, Qesiryazdin, Sharia, and Grshin (Bawerde), during both seasons in 2015 revealed that the extracted nematodes belong to *M. javanica* (*Fig. 5*) in all surveyed locations, and according to certain characters emphasized that the perennial patterns were for root-knot nematode (*M. javanica*). This result is consistent with

those of many nematologist researchers (4, 9, and 17) who found the same species in the infected cucumber roots.

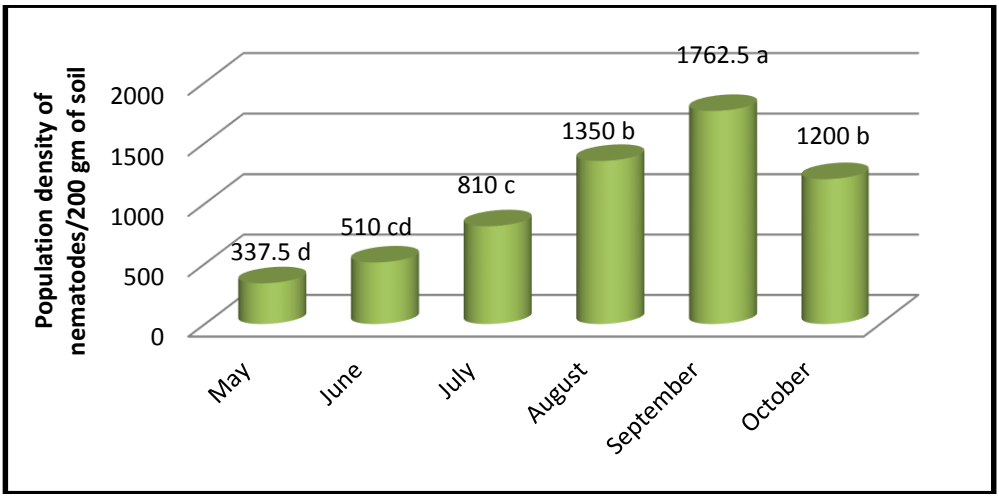

Figure 5. Monthly fluctuation of population density of *M. javanica* in one of the greenhouses in Sartenk location during 2015.
Means with different letters differ significantly based on Duncan's Multiple Range test (P≤0.05).
Each value is a mean of 4 replications.

4. Monthly fluctuations of nematode population density of root-knot nematodes in the greenhouse of Sartenk village in Semel District

The results revealed that the period of soil sampling has a significant effect on nematode population density in the soil, where it reached the highest level (1,762.5 nematodes/200 gm of soil) in September 2015 with significant differences as compared to the other months, followed by August (1,350 nematodes/200 gm of soil), whereas the lowest level of nematode population density (337.5 nematodes /200 gm of soil) was found in May during the same year (*Fig. 6*). The variation in nematode population density in the soil of Sartenk location during the study months was due to temperature values having a direct impact on nematode activity and reproduction and on nematode population density in the soil.

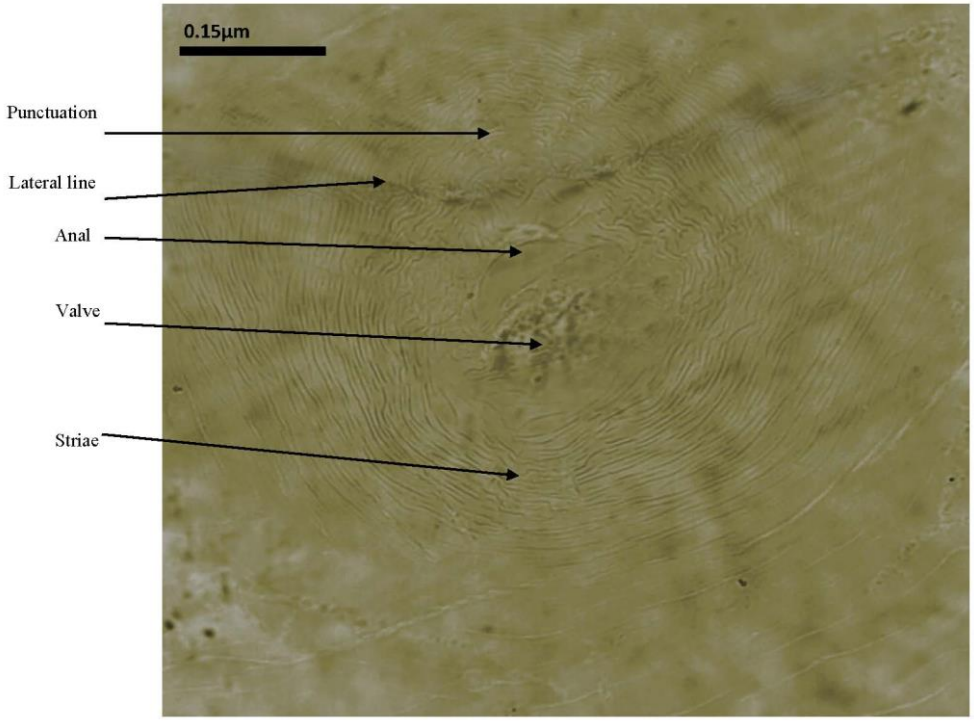

Figure 6. General morphology of perineal pattern of mature adult females of M. javanica

Thus, the increasing nematode numbers in September can be traced back to the suitability of soil temperature for nematode activity and egg hatching as well as the existence of susceptible hosts for root-knot nematodes, which caused an increase in nematode population density in the soil from summer until September. This is consistent with what have been recorded by Hussain et al. [14] and Ismail et al. [15]. The decrease in nematode population density in October was due to the death of infected cucumber plants as a result of severe damage of the root system at the end of the growing season in addition to the gradual decrease of soil temperature. This observation was supported by Ami and Al-Sabie [7]. On the other hand, the increase of nematode population density after May was attributed to the further development and reproduction of root-knot nematodes and the production of multiple generations during the growing season as a result of favourable soil temperatures for this nematode species, which is likely to have adapted to the soil temperatures for the greenhouse during the summer period besides the suitability of soil texture and the existence of susceptible hosts

(cucumber plants), which also indicates that the root system of cucumber plants did not deteriorate during this period of nematode parasitism.

4. Conclusions

1. Survey results showed the existence of root-knot disease in all greenhouses of summer plants by cucumber and the highest disease incidence was observed in the autumn growing season while the lowest in spring growing season.

2. Results of root-knot nematode associated with the identification of cucumber plants either by perineal pattern or molecular identification revealed that the widespread species of nematode was *M. javanica*.

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Beekeeping practice and honey production potential in Afar Regional State, Ethiopia

Gebrehaweria Kidane REDA,[1] Shishay GIRMAY,[2]
Belets GEBREMICHAEL[3]

[1]College of Agriculture and Environmental Sciences, Adigrat University,
Ethiopia P.O. Box 52 Adigrat, Ethiopia.
e-mail: gebrek2000@gmail.com (corresponding author)

[2]College of Dryland Agriculture, Samara University, Ethiopia
e-mail: shishaygirmay19@yahoo.com

[3]College of Agriculture and Environmental Science, Mekelle University, Ethiopia
e-mail: belets11@yahoo.com

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Abstract. The contribution of beekeeping is perhaps one of the most important income-generating activities for millions of smallholder farmers in Ethiopia. This study was intended to assess beekeeping practices and potential in three districts of Afar Region, northern Ethiopia. Primary data were collected from 120 respondents proportionally selected from each district. Semi-structured questionnaire were employed to collect the primary data. Focus-group discussion was also used to support interpretation of the interview data. Basically, descriptive statistics were used to analyse the data. All respondents use traditional honey production system despite some recent trials. The mean live colony ownership of the sample beekeepers is 10.08 colonies per household, with a maximum ownership of 62 colonies. The study showed that the annual honey production per beehive varies from 4 to 17 kg, with a mean production of 9.66 kg. The majority of the respondents harvest two times per year, while 18%, 19%, and 14.2% of the respondents harvest three, four, and five times per year respectively. This might be due to the special floral calendar of tropical plants found in the areas. 67.5% of respondents supplement their colonies during dry season. Producers travel more than seven kilometres to sell their honey. On average, beekeepers sell 77.86 kg per year individually, with a range of 0 to 353 kg. The main constraints of honey production in the area are recurrent drought, poor extension service, lack of access to improved technology, deforestation, etc. Therefore, it requires intervention to change the old beekeeping practices through training and introducing improved production systems.

Keywords: beekeeping, marketing, constraints, bee flora, Ethiopia

1. Introduction

Beekeeping is an important venture used for strengthening the livelihood of rural community. It generates a variety of production and respective assets [1]. It is a promising non-farm business, which contributes to smallholder's income and national economy. It has a substantial role in generating and diversifying the income of Ethiopian smallholder farmers. It is important mainly for small landholders and landless youths [2, 3]. Ethiopia is the home of diverse fauna due to its varied ecological and climatic conditions [4, 5]. This is the prime reason for the availability of large colony numbers in the country. In Ethiopia, three types of beehives (traditional, transitional, and improved) are known, with more than 10 million colonies, from which more than 70% are estimated to be colonized [6, 7]. Ethiopia is endowed with diverse agroclimatic zones, which are suitable for honey production. The annual honey and beeswax production is estimated around 53,680 and 4,700 tons respectively [8, 9], yielding 13% of the agricultural GDP [10]. The greater portion is harvested from traditional hives [11]. Accordingly, Ethiopia is ranked 10^{th} and 4^{th} in honey and beeswax production worldwide respectively [12, 13].

Thus, while the country is the principal producer of honey, it has the potential to improve yields and harvest more if existing beekeepers are able to overcome significant issues regarding inputs, technical skills, and climate change adaptation [14]. In order to exploit the country's production potential, the current government has given consideration to developing the beekeeping subsector as a strategy for the reduction of poverty and the diversification of export commodities [7]. Attention is also given to upgrading the knowledge and skill of development agents and beekeepers so that they can develop better apicultural knowledge and skills that enable them to improve traditional beekeeping and increase the production of hive products [15]. Moreover, different non-governmental organizations intervene to support the poor and the formation of beekeepers' cooperatives and unions to bring substantial changes to the increased supply and consistent quality of honey and beeswax that will subsequently enable the smallholders as well as the country to benefit from the subsector. Besides, the federal and regional agriculture and rural development bureaus have improvement strategies aimed at increasing the quality and quantity of hive products [7, 16].

Food insecurity is being exacerbated by the prolonged drought and accelerated frequency of shocks and stresses. This is bringing many communities deeper into a state of recurrent or chronic vulnerability and severe food insecurity [17, 18]. Northern Afar is located at the lowland peripheries of Ethiopia, where it is known for its short rain season, wherefore crop production is highly constrained.

The increase in the frequency of droughts has impaired livestock production and reproductive performance in the area. Hence, beekeeping is the best alternative that can fit the current problems. Beekeeping is an old alternative traditional practice in the area. The communities possess large numbers of honeybee colonies, almost all in traditional hives. Some households possess more than 100 colonies, which is somewhat impressive based on an external perception. The promotion of apiculture development is therefore necessary in the area where crop production is hindered due to low and erratic rainfall. Arid and semi-arid honeybees have fast build-up as well as a fast honey-storing tendency, which are adaptive values for survival in arid lowland environments where flowering duration is short due to short raining and extensive dry periods.

However, the extent of production potential of the apicultural practice and contribution to the income generation of the society, in particular for the regional and in general for the national economy, have not been investigated yet. Therefore, the assessment of beekeeping potential and practice is a prerequisite to promote beekeeping development.

2. Materials and methods

The study area

The study area is situated in zone two of Afar Regional State positioned from 12 0 53’ 59” to 140 33’ 27” North and 390 38’ 43” to 400 55’ 20” East. It is categorized under arid and semi-arid climate with low rainfall and drought proneness. Rainfall is bi-modal with an annual rainfall of 407.2 mm. Temperature varies from 18.3 °C to 32.1 °C in higher and lower elevations respectively, with a mean annual of 25.2 [19]. There are three rainy seasons in the area. About 60% of the rainfall received during the main rainy season, the “karma”, occurred from the end of June to early September; this is followed by rainy showers from the end of December to mid-January, locally termed “dada”. This is followed by a minor rainy period from the end of March to mid-April, called “sugum”. The mainstay of communities in the area is livestock production followed by crop cultivation and beekeeping. The main honeybee floras are *Leucas abyssinica*, *Hypostus auriculata*, *Becium grandiorum*, *Acacia mellifera*, *Acacia tortilis*, *Acacia Senegal*, *Dobera glabra*, *Ziziphus mucronata*, *Opuntia*, *Cordia sinensis*, *Aloe elegance*, *Bidens macroptera*, *Acacia pilispina*, etc. Beekeeping in the districts is practised almost traditionally with the locally available materials, and the areas have a potential for honey production.

Data collection and analysis

Purposive and probability sampling procedures were used. A two-stage sampling technique was employed to select a beekeeper respondent. Among the administrative districts of the northern zone of the region, three districts were selected purposively based on their well-situated agroecology for beekeeping and honey production potential. In the second stage – using the list of beekeepers in the sampled area –, 120 beekeeper households were randomly selected based on the probability-proportional-to-size principle. The lists of beekeepers acquired from the administrative districts were used as a sampling frame. Moreover, key informant interviews and focus groups were selected from the chosen pastoral associations. A pre-tested questionnaire in a preliminary survey was prepared. The questionnaire contained dichotomous, multiple choice, and open-ended questions.

Honeybee floras were first identified using the local name and then followed by field-trip physical identification. Unfamiliar plants were identified using the botanical field guides and flora books of Ethiopia and Eritrea [20]. The analytical tool employed for this study was descriptive statistics using the statistical package for social sciences (SPSS version 20).

3. Results and discussions

Beekeeping potential

The mean live colony ownership of the sample beekeepers is 10.08 colonies per household, with a maximum ownership of 62 colonies (*Table 1*). This result is lower than the number observed in the Jimma zone (35 colonies per household) [21] and similar to the number recorded by [22]. A higher number of colonies was recorded in comparison with other reports [13, 23–26]. Honeybee colonies are the second important assets available to most of the respondent beekeepers in the North Afar. The ownership of honeybees in the area is regarded as having a secured and healthy family. Beekeeping has various benefits that support the improvement of pastoralists' economic and nutritional requirements. Successful beekeepers make a substantial contribution to family income and food security [27]. On average, 10.12 empty hives were recorded in the study area, which is almost equivalent to the number of colonized hives (*Table 1*). More than 98.2% of the respondents attribute these empty hives to absconding due to the prolonged drought in the area (*Table 2*). This indicates that beekeepers are not aware of intensive colony management during the shortage of availability of honeybee forage, on the one hand, and less follow-up by extension workers when problem emerged, on the other.

Table 1. The number of colonies and the number of empty hives in the sample respondents' possession

Variables	Districts						Total	
	Koneba		Berahle		Dallol			
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Number of colonized traditional hives	7.00	4.93	12.50	13.59	10.56	11.38	10.08	10.87
Number of empty traditional hives	4.30	3.73	15.64	14.70	9.86	13.13	10.12	12.49
Number of empty modern hives	0.30	0.52	0.0	0.0	0.19	0.47	0.16	0.41

Std. Dev. = standard deviation

Out of the 120 surveyed beekeepers, 51.7% start beekeeping by hunting down their initial colonies in forests and mountains, which is different from the result reported in other parts of northern Ethiopia, where 88.8% of the beekeepers collect their colonies by catching either flying or jangle swarms [28]. More than 96% of the beekeepers in the Gamo Gofa zone, Ethiopia, also collected their foundation colony by catching swarms [29]. A study report in the Jimma and Illibabor zones of Oromia Regional State indicated that more than 50% of beekeepers start their bee farms by catching swarming colonies [22]. These findings generally indicate that there is no standard colony marketing.

Table 2. Initial sources of colonies, reasons for empty hives, and apiary centres

Variables	Responses	Koneba		Berahle		Dallol		Total	
		N	%	N	%	N	%	N	%
Initial source of colony	Hunting	17	42.5	26	59.1	19	52.8	62	51.7
	Purchased	3	7.5	2	4.5	2	5.6	7	5.8
	Inherited	20	50.0	2	4.5	13	36.1	35	29.2
	Hunting and inherited	0	0.0	4	9.1	0	0.0	4	3.3
	Inherited and purchased	0	0.0	10	22.7	2	5.6	12	10.0
Apiary centre	Backyard	29	72.5	44	100.0	30	83.3	103	85.8
	Far from home	11	27.5	0	0.0	6	16.7	17	14.2
Reason for the empty hives	Absconding	35	97.2	44	100.0	33	97.1	112	98.2
	Sold	1	2.8	0	0.0	1	2.9	2	1.8

N = number of respondents

On average, 85.8% of the beekeepers keep their colonies near to their homestead (*Table 2*). This indicates they have no isolated apiary far from their home. This may lead to the disturbance of domestic animals, family members, and the colonies themselves. Isolated apiary increases colony stability, which is a key factor in increasing honey production. A disturbed colony always focuses on guarding and defending its nest, rather than collecting honey. During group discussions, respondents reflected that repeated conflicts with neighbours took

place due to attacks on domestic animals by the bees and visa vice. More than 20% of beekeepers in the Gamo Gofa zone in the Southern Region of Ethiopia kept their colonies in a simple shed built for hive placement, which is considered an independent apiary centre [29].

Honey production and productivity

Honey was the major hive product produced in the study area. About 73.3% of the respondents produced only honey, while 24.2% both produced honey and raised colonies (for sale) (*Table 4*). The survey showed that the annual honey production per traditional beehive ranges from 2 to 17 kg, with a mean production of 9.66 kg. The production observed in the study area was nearly similar to the production observed in the Atsbi Wemberta [23] and Kolla-Tembien [30] districts of Tigray and in eastern Amhara Region [24], which is geographically and agro-ecologically nearer to the study areas. It was higher than the production reported in the eastern zone of Tigray regional state [31, 32], Hadiya zone [33], the Gamo Gofa area of Southern Ethiopia [29], Jigjiga zone of Somali regional sate [34], Jimma and Illubabor [22], and South West Shewa [35] zones of Oromia regional state. Higher productions were reported by other authors in another areas of Ethiopia [21, 30, 36, 37]. The difference may be due to the agro-ecological suitability, water availability, and level of awareness of the beekeepers for colony management.

The average annual honey production per household of the surveyed beekeepers was 88.75 kg within a range of 4–372 kg (*Table 3*), which is nearly similar to the production reported in Tigray regional state [23, 30]. A lower annual honey production (23.35 kg) per household was observed in the West Arsi zones of Oromia region [13]. The survey indicates that the area has a high potential for honey production if additional technological inputs and extension service are delivered to the desired level.

Table 3. Annual honey production per hive and per household

Variables	Koneba		Berahle		Dallol		Total	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Honey production per hive	9.33	3.29	10.30	3.25	9.22	3.01	9.66	3.20
Honey production per household	66.15	42.12	110.00	86.97	87.25	64.97	88.75	70.13

Std. Dev. = standard deviation

Harvesting season and harvesting frequency

The frequency and peak of harvested honey varies depending on colony management practices and the flowering condition of honeybee flora [38, 39]. The harvesting frequency varies from district to district due to differences in honeybee flora across the range of altitudes in the study area. About 40.9% of the sample respondents in Berahle District reported to harvest four times per year and 31.8% reported to harvest five times per year, which is different from the mean harvesting frequency in other parts of the country [12, 32, 35, 38, 40].

Table 4. Sample respondents' hive products, season harvest, and harvesting frequency

Variables	Responses	Koneba		Berahle		Dallol		Total	
		N	%	N	%	N	%	N	%
Type of hive products produced	Honey	38	95.0	22	50.0	28	77.8	88	73.3
	Bees wax	1	2.5	0	0.0	0	0.0	1	0.8
	Honey and beeswax	1	2.5	0	0.0	1	2.8	2	1.7
	Honey and colony	0	0.0	22	50.0	7	19.4	29	24.2
Harvesting frequency per year	Once	0	0.0	0	0.0	0	0.0	0	0.0
	Twice	25	62.5	6	13.6	17	47.2	48	40.0
	Three times	15	37.5	0	0.0	7	19.4	22	18.3
	Four times	0	0.0	18	40.9	5	13.9	23	19.2
	Five times	0	0.0	14	31.8	3	8.3	17	14.2
Peak season of production	[1]Karma	8	20.0	22	50.0	14	38.9	44	36.7
	[2]Jilal	30	75.0	0	0.0	15	41.7	45	37.5
	[3]Sugum	2	5.0	2	4.5	0	0.0	4	3.3
	Karma and Sugum	0	0.0	20	45.5	7	19.4	27	22.5

N = number of respondents

In this district, the main honeybee flora is mostly made up of shrubs and trees that bloom in different seasons throughout the year, which is different from the conventional flowering period due to summer rain. In a single season, they harvest five to six times. In Koneba District, 62.5% of the sample beekeepers reported to harvest twice a year, which is similar to the harvesting frequency reported in different parts of Ethiopia [15, 23, 41], while 37.5% harvest three times per year. In Dallol District, 47.2%, 19.4%, 13.9%, and 8.4% of the respondents harvest twice, three times, four times, and five times a year respectively. Differences in

[1] From July to August.
[2] From December to January.
[3] From April to May.

harvesting frequency within the same district might be due to differences in colony management.

A larger percentage (37.5%, 36.7%, and 22.5%) of respondents indicated that the peak seasons of harvest are Jilal and Karma followed by Sugum (*Table 4*). These seasons are found next to the longer summer rain and the spring short rain periods. The result is similar to the report in Kilite Awlaelo District in Tigray regional state [31].

The potential of honeybee flora and supplementation

Bee forage types affect the quantity and quality [42] of honey yield obtained per colony [30, 31, 33, 43]. According to the sampled beekeepers, the existence of some special honeybee floras in the study district results in the production of good-quality and high-quantity honey and increases the frequency of harvests. More than 65% of the respondents replied that bee forage is highly available, and none of the respondents reported a reduced availability (*Table 5*).

Table 5. Availability of honeybee flora and colony supplementation

Variables	Responses	Koneba		Berahle		Dallol		Total	
		N	%	N	%	N	%	N	%
Availability of bee forage	Less available	0	0.0	0	0.0	0	0.0	0	0.0
	Medium	12	30.0	18	40.9	12	33.3	42	35.0
	Highly available	28	70.0	26	59.1	24	66.7	78	65.0
Colony supplementation	Yes	14	35.0	44	100.0	23	63.9	81	67.5
	No	26	65.0	0	0.0	13	36.1	39	32.5
Season of supplementation	Dry season	14	100.0	44	100.0	23	100.0	81	100.0
	Rainy season	0	0.0	0	0.0	0	0.0	0	0.0
	Harvesting period	0	0.0	0	0.0	0	0.0	0	0.0

N = number of respondents

The districts are very special for their diversified shrubs, trees, and herbaceous species such as *Acacia mellifera*, *Ziziphus spina-christi*, *Ziziphus mucronata*, *Acacia horrid*, *Balanites aegyptica*, *Acacia tortilis*, *Grewia ferruginea*, *Grewia penicillata*, *Salvadora persica*, *Acacia nilotica*, *Acacia Senegal*, *Acacia seyal*, *Leucas abyssinica*, *Hypostus auriculata*, *Becium grandiorum*, *Dobera glabra*, *Opuntia*, *Cordia sinensis*, *Aloe elegance*, *Bidens macroptera*, *Acacia pilispina*, etc. These floral species are not similar with floras in other areas of Ethiopia [13, 22, 33, 41, 44–48]. The plants bloom in different seasons of the year,

which assures a continuous supply of food for bees. This contributes to an increased frequency of harvesting.

During the group discussion, participants expressed that the availability of herbaceous floras was decreasing from time to time due to the recurrent drought and overgrazing due to increasing population. A similar result was reported by [33]. Bees store honey during the honey flow period for consumption during the no flower period. However, according to the respondents, there is a high utilization of honey by beekeepers. For this reason, bees face lack of food in dry periods.

Table 6. The honeybee flora of the study area

Species name	Life form	Flowering
Acacia mellifera	Shrub/Tree	October–December, May
Ziziphus spina-christi	Tree	September–December
Ziziphus mucronata	Tree	November–January
Ziziphus abyssinica	Tree	December–February
Acacia tortilis	Tree	April–June
Acacia senegal	Tree	May–July, October–December
Hypostus auriculata	Herb	July–November
Leucas abyssinica	Herb	August–October
Aloe elegance	Shrub	August–October
Becium grandiorum	Shrub	June–August
Opuntia spp	Shrub	May–July
Acacia etbaica	Tree	September–November
Euphorbia abyssinica	Tree	October–December
Acacia nilotica	Tree	April and June, September–November
Acacia seyal	Tree	May–June
Grewia ferruginea	Shrub	May–July
Grewia penicillata	Shrub	June–July
Grewia villosa	Shrub	May–July, September–November
Grewia bicolor	Shrub	May–July
Acacia pilispina	Tree	November–December
Balanites aegyptica	Tree	April–June
Acacia horrida	Tree	March–June
Salvadora persica	Shrub	March–April
Cordia sinensis	Tree	December–February
Bidens macroptera	Herb	August–September
Indigofera spinosa	Herb	August–September
Crotolaria incana	Herb	August–September
Tephrosia villosa	Herb	August–September
Tribulus terrestris	Herb	August–September
Ocimum lamifolium	Herb	August–September
Cynodon dactaylon	Herb	August–September

To overcome starvation during the period of flower scarcity, some beekeepers take different solutions such as supplementary feeding and migratory practices, taking them to areas with good sources of flowering plants, which is also supported by another study [31]. In the study area, 67.5% of the total respondents supplement their colonies during the dry period, from February to March. This result is supported by [25, 32, 46], while in the Guji and Borena zones of Oromia regional state only 37.67% of the respondents supplement their colonies [43]. The results were 100%, 63.7%, and 35% in Berahle, Dallol, and Koneba districts respectively. The type of feed they supplement were mainly sugar followed by roasted spiced bean flours (shuro). Beekeepers in Berahle also practised migratory beekeeping. They take their colonies to areas with better access to bee forage and water, mainly large mountains and irrigated areas. During group discussions, all beekeepers responded that they had inspected their colonies for disease and pests. They also practise certain treatments such as fumigation by some type of woody plant, such as olive, which are expected to have medicinal value.

Honey marketing

In this study, market information was defined as the awareness of people regarding where, how, when, for whom, and at what price honey is sold. Accordingly, 94% of the sample respondents gathered honey market information via people-to-people social information exchange system, which is locally called *Xaagu*. This information exchange system is highly powerful and allows the simple transmission of urgent information within a short period of time to a wider society.

As a result, pastoralists sold their pastoral products in the nearby market immediately after harvest to cover their production costs, social responsibilities, and direct family expenditures. The result shows that sample beekeepers were located at a distance between 2 and 16 km with an average distance of 7.4 km from their residence to the nearest market place (*Table 8*). The distance of the respondents from the nearest market centre measured either in minutes of walking or kilometres is one of the indicators of market accessibility. The above distance is shorter than the values observed in other parts of Northern Ethiopia [49].

In marketing, the surplus from the total produced commodities is more important; and market expansion has to be made for the surplus product. The rate at which pastoral production increases regulates the degree of pastoral livelihood improvement, whereas the growth in the marketable product determines the degree of economic improvement. The surplus product is the remained crop with the producer pastoralists after fulfilling their home consumption and payment requirements.

Table 7. Marketing information

Variables	Response	Koneba		Berahle		Dallol		Total	
		N	%	N	%	N	%	N	%
Marketing information	Yes	37	30.8	44	36.7	31	25.8	113	94.2
	No	3	2.5	0	0.0	4	3.3	7	5.8
Honey market participation	Yes	33	27.5	42	35.0	31	25.8	106	88.3
	No	7	5.8	2	1.7	5	4.2	14	11.7
Honey sales responsibility	Men	29	27.4	34	32.0	22	20.7	85	80.2
	Women	4	3.7	8	7.5	9	8.5	21	19.8
Market place accessibility	Farm gate	10	9.4	16	15.0	9	8.5	35	33.0
	Nearby market	23	21.7	26	24.5	22	20.7	71	67.0

N – Frequency, % – percentage

In essence, among the beekeeper respondents, 88% were involved in selling their raw honey surplus leftover, home-consumed by the family members and offered as gift for others. Due to the appreciable nature of honey regarding time, that is, the shelf-life of honey (which is longer than that of livestock products), beekeepers can sell it anywhere at any time to their customers. The amount of honey sold is also different from beekeeper to beekeeper due to the number of beehives, their colony-holding capacity, productivity per hive, and the amount of honey consumed at home and offered as gift to others. Accordingly, the sample beekeepers sold honey ranging from 0 Kg to 353 Kg, with a mean of 77.86 kg per year per household at a mean price between 150 ETB (7 USD) and 200 ETB (9 USD) per Kg over the study year (*Table 8*).

Table 8. Distance to market and the amount of marketed honey consumed

Variable	Koneba		Berahle		Dallol		Total	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Distance from market	4.53	1.11	10.27	4.52	7.14	4.32	7.42	4.37
Amount of honey sold per household	51.87	35.19	103.07	81.67	75.19	63.67	77.86	67.04
Price per kg	181.28	16.09	185.00	16.91	182.22	17.26	182.94	16.69
Consumed honey per household per year	14.77	10.45	6.98	7.54	12.08	10.72	11.08	10.05

Std. Dev. = standard deviation

The price of honey in the study area was more than 100% higher than the price in other areas of the country in the same year [21, 25, 29, 33, 50, 51]. The reason for the high price of honey in the area is due to the high-quality special honey owing to the floral species. Consumers can find a special honey from one or

two flowering plants, which can be purchased and consumed for a specific treatment. For example, people who need honey from *Ziziphus mucronata* can get it prepared only from *Ziziphus mucronata*, which is generally used as coughing medication.

Most of the producers sold their honey at the nearby market (67%), whereas 33% of them sold it at their farm gates. This result is in line with the report of [13, 50]. More duties related to honey selling fall to the men (80%) than the women (20%) (*Table 7*). On average, 11.08 kg of honey is either consumed within the household and/or given away to family relatives, which means about 12.5% of the produced honey was not supplied to the market. The percentage of honey sold is higher than that of reported in Arsi zone of Oromia region [13], where 45% of the honey produced was used for home consumption.

Major constraints of honey production

Nowadays, beekeepers are facing a number of difficulties and constraints that limit the efficiency of honey production. Respondents raised a number of constraints that hinder beekeeping in their area. The major challenges and constraints recognized in the target area are listed in *Table 9*. Poor extension service, enemies and disease, shortage of water, poor knowledge, and shortage of improved technology are the top-ranked constraints. The rank of constraints in the study area is different from constraints ranked in other parts of the country [21, 25, 45, 50, 52–54]. The difference might be due to the different agro-ecological characteristics and production system.

Table 9. Major beekeeping constraints in the study area

Constraints	Rank by frequency												Overall ranking
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	
Poor extension services	40	45	15	10	3	3	4						1st
Lack of knowledge	18	2	20	39	11	12	7	2	5		3	1	4th
Recurrent drought	1	1	5	16	15	33	20	10	6	6	4	3	6th
Deforestation	2	1	5	5	10	17	36	20	11	7	2	4	7th
Lack of improved technologies	7	2	15	20	38	15	5	5	1	5	3	4	5th
Poor infrastructures		1		5	11	12	22	40	13	7	9		8th
Pest, predators, and diseases	32	42	20	5	10	7	1	1	2				2nd
Chemical application		3		3		1	1		12	12	26	62	12th
Shortage of bee flora		1		2		2	8	10	23	45	14	15	10th
Lack of credit		1	7	5	7	11	13	17	35	15	4	5	9th
Market inaccessibility								11	10	21	55	23	11th
Shortage of water	20	21	33	10	15	7	3	4	2	2		3	3rd

Number of respondents – 120

Opportunities of beekeeping

There is large number of bee floral species in each season of the year in every location of the study area. The demand of hive products for domestic use and export market is constantly on the rise. Currently, government and non-government organizations largely support natural resource conservation programmes within which beekeeping is encouraged. A rich culture, a proper perception of the society of beekeeping, a favourable environment with a diverse agro-ecology, indigenous knowledge, a high interest in accepting improved beekeeping systems, and undertaking apiculture as a mainstay are just a few opportunities worth mentioning.

4. Conclusions

Honeybees are the second important assets available to most of the respondent beekeepers in North Afar. Beekeeping has many advantages that help the people of the area to improve their economic and nutritional requirements. The ownership of honeybees in the area is regarded as having a secured and healthy family. This is a good asset for the community to scale up the business. The relatively high number of colonies per household in the area, though all in traditional hives, is also an opportunity. More than half of the households start beekeeping by collecting wide colonies due to the lack of a systemic/organized supply of colonies on the market and a lack of community awareness regarding selling colonies.

None of the respondents have colonies in modern hives, which indicates that modern hives are not well promoted in the area due to the poor involvement of extension agents. This might be due to the less involvement of extension agents in supporting the beekeepers and training them in terms of strategies. The strategic model of assigning trained experts to deliver institutional services, and thereby adopt improved technologies, was not successful in the region. Therefore, beekeepers should be provided sufficient information on the drawbacks of traditional beekeeping and the benefits of modern apiculture, using community-based education. Moreover, this requires an intervention on the part of the government and other organizations – through practical trainings, extracting indigenous knowledge, etc. – to adopt improved beekeeping practices.

Due to the large number of special tropical plants found in the areas, harvesting frequency is higher than in most of the researched environments of the country. Despite the problems faced by the apiculture sector, there are a number of opportunities to improve this venture and to increase the outputs of the activity. This is important for a sustainable improvement of the community's life. Beekeepers should be capable of preparing their bee colonies for consecutive harvesting and the regular inspection and assurance of the colonies. According to the survey, the honey marketing system in the area was found to be traditional. The

producers do not profit from the marketing systems. Thus, honey producers should be organized into producers' cooperative societies. This would enable producers to manage the prices of products. Attention should be paid to diversification of hive products and added values. In the area, wax is not produced due to lack of awareness of the importance of the product and absence of processing equipment and technical abilities. Therefore, awareness should be created on the value of beeswax and other hive products. This may ensure proper benefit from the business.

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Effects of discharge from carwash on the physico-chemical parameters and zooplanktonic abundance of Odo-Ebo River, Ile-Ife, Nigeria

Oluwakemi Elizabeth ODEYEMI,[1] Adebukola Adenike ADEDEJI,[2*] Olatunji Joshua ODEYEMI[2]

[1] Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria

[2] Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria

[3] Department of Environmental Biology and Public Health, Federal University of Technology, Akure, Nigeria

*Corresponding author: +234-805-532-7066; bbkadedeji@yahoo.com; bbkadedeji@oauife.edu.ng

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Abstract. The study determines the physico-chemical parameters of water from Odo-Ebo River with a view to providing information on the effects of discharge from carwash on the River's water quality. Samples (48) for physico-chemical water quality were collected monthly over a period of an annual cycle (February 2015–January 2016) from four stations, namely: upstream (about 500 m before the carwash), two discharge points (1st and 2nd discharge points), and downstream (about 500 m after the carwash). The discharge points had higher mean values in 9 out of the 13 investigated water quality parameters, especially plant nutrient ions (phosphate, nitrate, and sulphate), with the discharge points significantly differing from the other stations in terms of phosphate concentration and apparent colour. This led to reduction in dissolved oxygen and zooplankton abundance, changes in apparent water colour, and increase in COD at the effluent receiving points. Furthermore, the higher mean values of dissolved oxygen, BOD_5, turbidity, and true colour recorded upstream and downstream were reflections of higher biological productivity and organic detritus at these stations as compared to discharge points. The specific presence of some eutrophic species at the discharge points has only further proven the negative effects the effluent from the carwash had on the river, thus posing a potential threat to its aquatic organisms' diversity. This eutrophication effect was observed downstream as an increase in zooplankton abundance and diversity. Therefore, environmental protection regulations are needed to reduce anthropogenic influence on the rivers in Nigeria.

Keywords water quality, diversity, eutrophic species, carwash, discharge points

1. Introduction

Freshwater habitats occupy a relatively small portion of the Earth's surface as compared to marine and terrestrial habitats, but their importance for man is far greater than their areas [1]. However, freshwater has become a scarce commodity due to overexploitations and pollution [2, 3, 4]. Reservoirs, rivers, streams, and lakes that constitute 55% of freshwater are vulnerable to pollution as a result of various human activities, which are capable of destroying the quality of waters and their inhabiting organisms [5, 6]. Moreover, rivers are used as sites for refuse disposal, human sewage, and waste water from kitchens, abattoirs, and industrial sites [7]. Likewise, water bodies running through areas of significant human impact, such as farms, urban settlements, and industrial locations, are susceptible to pollution [7]. In most developing countries, discharge of effluent from factory, farm, commercial establishments, or households into water bodies, such as rivers, streams, lakes, or lagoons, has become a serious problem due to increase in urban and industrial development [8]).

Surfactants and other ingredients of detergents are common constituents in domestic and municipal effluents, which ultimately reach the natural environment and cause various toxicities to aquatic organisms [9, 10]. Thus, detergent wastes can have poisonous effects on all types of aquatic life if they get accumulated in sufficient quantities [11]. Detergents could also affect receiving aquatic environments by causing foaming and eutrophication, therefore limiting oxygen production [12]. The hazard of detergent pollution also lies in their effect on water ecosystems as a whole for surfactants may adversely affect microalgae at the lowest trophic level, impacting their function as major suppliers of oxygen to water bodies and result in community structure infringement [13].

Therefore, contamination of water bodies by discharge is viewed as a worldwide issue due to its effects on the ecosystem. In Nigeria, it is a significant challenge due to the attitude of the populace and industries towards effluent disposal and management [14]. In view of this, discharges from car wash and other anthropogenic sources might result in serious threat to the lives that inhabit the water body. Hence, the discharge level of detergents of domestic and industrial wastewater should be monitored so as to prevent environmental degradation. Therefore, this study seeks to identify and evaluate the impact of car wash sited along a river bank on the receiving ecosystem.

2. Materials and methods

Study area and sampling sites

Odo-Ebo River is one of the rivers that flow within Ile-Ife, Osun State. The river was divided into upstream, discharge points, and downstream. The river upstream, where less human activities were observed, is located at latitude 07°29.290′′N and longitude 004°32.326'E, with an elevation of 267 m (***Fig. 1***). The first discharge point where effluents flow into the river is located at latitude 07°29.294'N and longitude 004°32.327'E, with an elevation of 266 m, while the second discharge point is located at latitude 07°29.308'N and longitude 004°32.318'E, with an elevation of 266 m. The car wash workshops were located at these discharge points. The river downstream station was sited close to an abattoir at latitude 07°29.313'N and longitude 004°32.306'E, with an elevation of 262 m.

Sample Collection

Samples were collected monthly from the four sampling stations for a period of 12 months for physico-chemical water quality and planktonic analysis. On the field, air temperature and water temperature were determined *in-situ* using mercury-in-glass thermometer. Samples for dissolved oxygen and 5-day biological oxygen demand (BOD_5) were collected in oxygen bottles (125/250 ml reagent bottles). Dissolved oxygen samples were fixed immediately upon collection with Winkler's reagents (manganous sulphate and potassium iodide). BOD_5 samples were collected in black reagent bottles and kept in a dark cupboard at room temperature (about 27± 2°c) for 5 days, after which they were treated for oxygen determination.

Physico-chemical analysis

Water samples (36 samples) collected in 2-litre polyethylene jerry cans were used for the determination of other chemical parameters. The samples were analysed for true colour, apparent colour, and turbidity using the colorimetric method [15]. The chemical analysis of the water samples was in accordance with the standard methods of Golterman et al. (1978) [16], Mackereth et al. (1978) [15], Ademoroti (1996) [17], and APHA et al. (2000) [18], as applicable. The chemical parameters analysed include a major ion (SO_4^{2-}), salinity parameters (alkalinity, conductivity), plant nutrient (nitrate, PO_4^{3-}), and oxygen parameters (DO, BOD_5, and COD).

Samples for zooplankton analysis were collected by straining 30 litres of water through a fine-meshed plankton net (mesh size = 45 μm) to a concentrate volume of 30 ml preserved with 5% formaldehyde and Lugol's solution in a specimen bottle for later examination and identification.

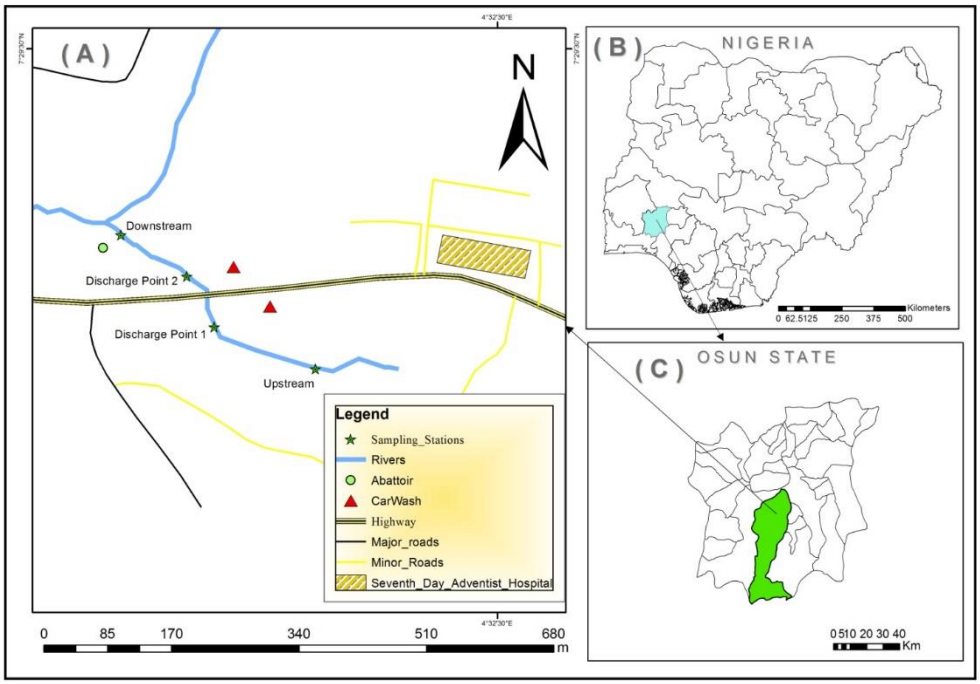

Figure 1. Map showing Nigeria map (A), Osun state map (B), and sampling points' locations at Ile-Ife (C)

These preserved samples containing plankton were examined in the laboratory using Omax binocular light compound microscope and their scaled pictures taken by placing 1 ml in a plankton chamber. Measurements and enumeration of the recorded plankton were also made.

The recorded zooplanktons were identified using standard identification guides, which include the works of Jeje and Fernando (1985) [19], Fernando (2002) [20], and Suthers and Rissik (2009) [21]. The abundance of each plankton species per unit volume of the original water source was estimated based on the records obtained. Abundance of each species was determined using the following equation:

$$A = \frac{ab}{c} \times 1000,$$

where:

A– abundance of species per litre of original water source,
a – abundance of species in the counting chamber,
b – total concentration volume of water used (1 ml), and
c – triginal volume of water (l).

Statistical analysis

The data collected were subjected to various descriptive and inferential analyses, such as the means, standard deviations, analysis of variance, t-test, and correlation, to test the effects of car wash discharge on Odo-Ebo River's water quality and planktonic abundance both temporally and spatially, as applicable, using SPSS 21.

3. Results

The values of temperature (air and water) and salinity were within a very narrow range with their coefficients of variation being less than 10%, while the coefficients of variation recorded for oxygen parameters (DO, BOD5, and COD), major ions (phosphate, sulphate, and nitrate), and other hydro-physical conditions (alkalinity, turbidity, true colour, and apparent colour) were greater than 50%, showing a wide dispersion of values around their mean (*Table 1*). The wide range was more pronounced in sulphate concentrations recorded with CV greater than 1 in all the stations investigated (*Table 1*). This variation was also revealed in the percentage differences of 2% to 32% increase in the sulphate concentration among the sampled stations. The highest percentage increase in sulphate was between upstream and downstream, followed closely by an increment of 30% observed between upstream and Discharge Point 2, while the lowest increment was observed between Discharge Point 2 and downstream, thus reflecting the effects of the effluent on the sulphate concentration of the water body.

In general, in 9 of the 13 investigated water quality parameters, the discharge points were characterized by higher mean values than those of the upstream and downstream sections. For these 9 parameters (water temperature, pH, conductivity, chemical oxygen demand, alkalinity, phosphate, sulphate, nitrate, and apparent colour), the discharge points differed from 10% to 13% on the average in comparison with other stations. The major ions (phosphate, sulphate, and nitrate) were also, on the average, 17% higher in concentration (2% to 30%) at the discharge points than upstream and downstream. On the other hand, only 4 parameters (DO, BOD_5, turbidity, and true colour) had higher means (13% to 30% higher on the average) upstream and downstream.

The effect of the effluent was also observed temporally with 8 of the 13 assessed parameters (conductivity, DO, COD, BOD_5, alkalinity, sulphate, turbidity, and true colour) having higher mean concentration during the rainy season, while phosphate and nitrate recorded higher mean concentrations during the dry season. Notably, among these parameters was sulphate, whose mean concentration during the rainy season was 400% higher than its recorded concentration in the dry season (*Table 1*).

Table 1. Descriptive statistics of the physico-chemical water quality parameters of Odo-Ebo River between February 2015 and January 2016

Parameters	Temporal average				Spatial average								Overall		Effluent discharges, irrigation, and reuse standards [22]	
	Rainy season		Dry season		Upstream		Discharge Point 1		Discharge Point 2		Downstream					
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Min	Max	Mean	
Air Temperature (°C)	26.02	4.46	26.88	3.32	26.88	4.67	26.18	4.32	26.03	4.15	26.42	3.77	24.00	28.80	26.38	
Water Temperature (°C)	26.08	2.75	26.00	3.16	26.09	1.78	26.11	3.44	26.38	2.95	25.60	2.67	24.00	27.20	26.05	< 40
pH	7.06	5.57	7.17	3.36	6.92	5.95	6.99	5.91	7.26	2.05	7.26	2.18	5.80#	7.55	7.11	6.5–8.5
Conductivity (μScm^{-1})	442.61	5.03	439.15	5.70	429.00	3.76	439.00	4.46	450.00	7.01	447.00	4.28	400.00	490.00	441.17	1,000
Dissolved oxygen (mg/l)	5.17	41.42	4.11	60.69	4.93	56.97	4.51	43.37	4.07	55.46	5.40	42.67	0.40#	10.00	4.73	> 4
Biological oxygen demand (mg/l)	2.56	54.00	1.90	77.25	2.67	68.25	1.91	54.55	1.66	54.28	2.92	54.27	0.34	6.70	2.29	< 6
Chemical oxygen demand (mg/l)	39.92	58.96	26.76	58.46	35.65	77.09	35.77	47.08	36.69	45.27	29.63	83.83	6.87	96.30	34.44	30
Alkalinity ($CaCO_3$ mg/l)	99.93	28.45	95.05	22.92	86.92	11.15	106.00	38.75	98.75	25.81	99.92	13.70	62.00	200.00	97.90	50–200
Phosphate (mg/l)	33.28*	9.30	38.73*	19.87	33.95*	12.78	40.12*	23.99	34.54*	10.06	33.60*	5.17	28.00*	52.67*	35.55	3.5
Sulphate (mg/l)	23.25	86.80	5.78	50.58	13.17	100.82	16.14	112.24	17.12	121.27	17.44	113.20	1.50	60.86	15.97	500
Nitrate (mg/l)	5.27	46.32	6.31	62.19	4.97	37.04	6.00	63.03	6.38	64.97	5.44	45.66	2.44	16.86	5.70	40
Turbidity (NTU)	89.01*	51.08	44.48	62.57	78.62*	64.59	76.21*	72.44	61.18*	59.90	65.81*	55.21	3.43#	219.17*	70.45	30-60
True colour (Pt Co)	84.43	22.31	91.40	8.51	87.75	11.61	87.08	24.44	86.17	19.89	88.33	14.92	37.00	107.00	87.33	
Apparent colour (Pt Co)	96.64	8.05	92.25	4.77	89.83	5.24	95.92	7.08	95.25	5.15	98.25	8.43	80.00	120.00*	94.81	< 100

NB: * values higher than the desirable limit; # values lower than the desirable limit; CV – coefficient of variation

Table 2. Temporal and spatial variations in the physico-chemical water quality parameters of Odo-Ebo River, Ile-Ife, Osun State, Nigeria

Parameters	Rainy season Mean ± SD	Dry season Mean ± SD	F- Value	Prob.	Upstream Mean ± SD	Discharge Point 1 Mean ± SD	Discharge Point 2 Mean ± SD	Downstream Mean ± SD	F- value	Prob.
Air Temperature (°C)	26.02 ± 1.16	26.88 ± 0.89	8.316	0.006	26.88 ± 1.26	26.18 ± 1.13	26.03 ± 1.08	26.42 ± 1.00	1.766	0.169
Water Temperature (°C)	26.07± 0.72	26.00 ± 0.82	0.131	0.719	26.09 ± 0.46ab	26.11 ± 0.90ab	26.38 ± 0.78a	25.60 ± 0.68b	2.092	0.117
pH	7.06 ± 0.39	7.17 ± 0.24	1.520	0.225	6.92 ± 0.41a	6.99 ± 0.41a	7.26 ± 0.15b	7.26 ± 0.16b	3.348*	0.028
Conductivity (μScm^{-1})	443 ± 22.27	439 ± 25.05	0.261	0.612	429 ± 16.09a	439 ± 19.57ab	450 ± 31.56b	447 ± 19.14ab	1.840	0.155
Dissolved oxygen (mg/l)	5.17 ± 2.14	4.11 ± 2.49	2.402	0.129	4.93 ± 2.8	4.51 ± 1.95	4.07 ± 2.26	5.40 ± 2.30	0.737	0.536
Biochemical oxygen demand (mg/l)	2.56 ± 1.39	1.90 ± 1.47	2.680	0.109	2.67 ± 1.82ab	1.91 ± 1.04ab	1.66 ± 0.90a	2.92 ± 1.58b	2.537	0.070
Chemical oxygen demand (mg/l)	39.91 ± 23.54	26.75± 15.64	4.212*	0.047	35.65 ± 27.48	35.77 ± 16.84	36.69 ± 16.61	29.63 ± 24.84	0.268	0.848
Alkalinity ($CaCO_3$ mg/l)	99.93 ± 28.43	95.05 ± 21.74	0.394	0.534	86.92 ± 9.69	106.00 ± 41.06	98.75 ± 25.49	99.92 ± 13.69	0.994	0.405
Phosphate (mg/l)	33.28 ± 3.09	38.73 ± 7.70	63.789**	0.000	33.95 ± 4.34a	40.12 ± 9.62b	34.54 ± 3.47a	33.60 ± 1.74a	30.799***	0.000
Sulphate (mg/l)	23.25 ± 20.18	5.77 ± 2.92	13.065**	0.001	13.17 ± 13.27	16.14 ± 18.15	17.12 ± 20.77	17.44 ± 19.75	0.121	0.947
Nitrate (mg/l)	5.26 ± 2.44	6.31 ± 3.92	1.191	0.282	4.97 ± 1.84	6.00 ± 3.78	6.38 ± 4.14	5.44 ± 2.49	0.556	0.647
Turbidity (NTU)	89.01 ± 45.47	44.48 ± 27.83	13.685**	0.001	78.62 ± 50.78	76.21 ± 55.21	61.18 ± 36.64	65.81 ± 36.33	0.430	0.733
True colour (Pt Co)	84.43 ± 18.83	91.40 ± 7.78	2.176	0.148	87.75 ± 10.16	87.08 ± 21.28	86.17 ± 17.14	88.33 ± 13.18	0.012	0.998
Apparent colour (Pt Co)	96.64 ± 7.78	92.25 ± 4.40	6.100*	0. 018	89.83 ± 4.71a	95.92 ± 6.79b	95.25 ± 4.90b	98.25 ± 8.29b	3.886*	0.016

NB: * significant difference; ** highly significant difference. Values in a row followed by different letters are significantly different at p ≤

Despite these temporal and spatial variations in the mean concentration of the studied parameters, only 3 parameters (pH, phosphate, and apparent colour) showed statistically significant differences among the stations ($p < 0.05$) (*Table 2*), while temporally only 5 parameters, namely COD, phosphate, sulphate, turbidity, and apparent colour, showed statistically significant difference between the two seasonal cycles studied (*Table 2*). The result of Duncan's post-hoc test revealed further effects of the effluent, with the discharge points significantly differing from the other stations in terms of phosphate concentration and apparent colour (*Table 2*).

The effect of the effluent was also revealed in the diversity and abundance of organisms recorded both temporally and spatially. Although the discharge points had lower zooplankton abundance as compared to upstream (*Table 3*), these stations were more diverse in terms of number of species than determined by Margalef's index for species richness of 1.59 (14 species) and 1.55 (13 species) for discharge points 1 and 2 respectively as well as the low values of Simpson's index (*Table 3*) indicating the effluent's effect.

Moreover, the highest zooplankton abundance (4,800 Org/m3) and Margalef's index (2.01) was recorded downstream from 18 species, thus implying the flow of the effluent. The species recorded were, however, evenly distributed in all stations based on the evenness index and Hill's diversity indices determined, which showed that on the average 82.5% of the recorded species contributed to the total abundance. Temporally, the species were also evenly distributed with 79.5% of the recorded species contributing to abundance on the average. A higher abundance (9,900 Org/m3) and species richness (3.15) was recorded during the rainy season from 30 species as compared to 12 species (4,900 Org/m3) recorded during the dry season (*Table 3*).

All the 31 species recorded were represented during the rainy season except *Anuraeopsis fissa*, while only 12 species were recorded during the dry season. Of the total species recorded, 9 species were only recorded from discharge points, namely *Anuraeopsis fissa*, *Filinia terminalis*, *Keratella ticninensis*, *proales* sp., *trichocerca ruttneri*, *brachionus quadridentatus*, *spirostomium* sp., *Loxodes* sp., and *centropyxis aculeate* (*Table 3*), while 10 species were recorded only from other stations, with 5 species from downstream, 3 species from upstream, and 2 species from both stations (*Table 3*). Despite the variations in abundance and diversity recorded among the stations, only 3 species, namely *Coleps* sp., *Ostracoda* sp., and *Arcella vulgaris*, showed significant difference in mean abundance (*Table 4*). The t-test performed to find the main effect of the season also showed that the abundance of 11 species of the 31 species recorded varied significantly with season ($0.05 \geq p \geq 0.001$) (Table 4).

Table 3. Spatial and temporal total abundance of zooplankton species

Organisms	TEMPORAL		SPATIAL			
	Rainy season	Dry season	Upstream	Discharge Point 1	Discharge Point 2	Downstream
Anuraeopsis fissa	0	800	0	300	500	0
Asplanchnopus	300	400	200	300	0	200
Brachionus ureolaris	100	800	0	200	0	700
Ascomorpha ovalis	500	500	0	200	300	500
Asplanchna sp.	300	200	300	0	100	100
Elosa worrali	800	800	0	1100	300	200
Hexarthra mira	1,100	0	700	0	100	300
Synchaeta stylata	400	0	0	200	100	100
Filinia terminalis	100	0	0	100	0	0
Keratella ticinensis	100	0	0	0	100	0
Asplanchna sieboldi	100	0	0	0	0	100
Notholca accuminata	300	0	0	0	0	300
Proales sp.	400	0	0	200	0	200
Brachionus dimitiatus	400	0	0	0	0	400
Trichocerca ruttneri	300	0	0	200	100	0
Brachionus quadridentatus	100	0	0	0	100	0
Asplanchna brightwelli	100	0	100	0	0	0
Asplanchna priodonta	600	0	100	0	0	500
Arganotholca faliaea	500	0	300	0	0	200
Lecane leotina	400	0	200	200	0	0
Testudinella berzinzi	100	0	0	0	0	100
Epiphane brachionus	100	0	0	0	0	100
Conochilus unicornis	300	300	0	0	100	500
Spirostomium	100	0	0	100	0	0
Loxodes sp.	100	0	0	0	100	0
Coleps sp.	900	400	800	0	300	200
Ceratopogonid larva	200	200	100	100	100	100
Ostracoda sp.	200	100	300	0	0	0
Centropyxis aculeate	200	0	0	200	0	0
Arcella vulgaris	400	100	500	0	0	0
Amoeba radiosa	400	300	500	200	0	0
Mean	**330**	**418**	**342**	**257**	**177**	**267**
Total Abundance	**9,900**	**4,900**	**4,100**	**3,600**	**2,300**	**4,800**
Number of species identified	**30**	**12**	**12**	**14**	**13**	**18**
Margalef's index (r1)	**3.15**	**1.30**	**1.32**	**1.59**	**1.55**	**2.01**
Simpson's index (λ)	**0.05**	**0.12**	**0.12**	**0.13**	**0.12**	**0.08**
Shannon's index (H)	**3.15**	**2.29**	**2.27**	**2.36**	**2.36**	**2.69**
Hill's 1st diversity number	**23.22**	**9.89**	**9.72**	**10.59**	**10.55**	**14.69**
Hill's 2nd diversity number	**19.07**	**8.68**	**8.38**	**7.46**	**8.70**	**12.55**
Evenness index 4	**0.82**	**0.88**	**0.86**	**0.71**	**0.83**	**0.85**
Evenness index 5	**0.81**	**0.86**	**0.85**	**0.67**	**0.81**	**0.84**

Table 4. Spatial and temporal variation in the abundance of recorded zooplankton species

Zooplanktons	Rainy season Mean ± SD	Dry season Mean ± SD	F- Value	Prob.	Upstream Mean ± SD	Discharge Point 1 Mean ± SD	Discharge Point 2 Mean ± SD	Downstream Mean ± SD	F -Value	Prob.
Anuraeopsis fissa	0.00 ± 0.00	40.00 ± 99.47	25.979****	0.000	0.00 ± 0.00	25.00±86.60	41.67 ± 99.62	0.00 ± 0.00	0.559	0.646
Asplanchnopus	10.71 ± 56.70	20.00 ± 61.56	1.044	0.312	16.67 ± 57.74	25.00 ± 86.60	0.00 ± 0.00	16.67 ± 57.74	0.653	0.587
Brachionus ureolaris	3.70 ± 19.25	40.00 ± 82.08	30.771****	0.000	0.00 ± 0.00	18.18 ± 60.30	0.00 ± 0.00	58.33 ± 90.03	2.339	0.093
Ascomorpha ovalis	17.86 ± 66.96	25.00 ± 55.01	0.217	0.644	0.00 ± 0.00	16.67 ± 57.74	25.00 ± 86.60	41.67 ± 66.86	0.526	0.668
***Asplanchna* sp.**	10.71 ± 31.50	10.00 ± 30.78	0.025	0.876	25.00 ± 45.23	0.00 ± 0.00	8.33 ± 28.87	8.33 ± 28.87	1.045	0.386
Elosa worrali	28.57 ± 71.27	42.11 ± 183.53	0.979	0.328	0.00 ± 0.00	91.67 ± 239.16	25.00 ± 86.60	16.67 ± 38.93	1.285	0.297
Hexarthra mira	40.74 ± 144.81	0.00 ± 0.00	6.721***	0.013	58.33 ± 202.07	0.00 ± 0.00	8.33±28.87	25.00 ± 86.60	1.063	0.379
Synchaeta stylata	14.29 ± 44.84	0.00 ± 0.00	8.699***	0.005	0.00 ± 0.00	16.67 ± 57.74	9.09 ± 30.15	8.33 ± 28.87	0.559	0.646
Filinia terminalis	3.57 ± 18.90	0.00 ± 0.00	3.062	0.087	0.00 ± 0.00	8.33 ± 28.87	0.00 ± 0.00	0.00 ± 0.00	0.970	0.415
Keratella ticinensis	3.57 ± 18.90	0.00 ± 0.00	3.062	0.087	0.00 ± 0.00	0.00 ± 0.00	8.33 ± 28.87	0.00 ± 0.00	0.820	0.493
Asplanchna sieboldi	3.57 ± 18.90	0.00 ± 0.00	3.062	0.087	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	8.33±28.87	0.960	0.424
Notholca acuminata	10.71 ± 31.50	0.00 ± 0.00	11.880****	0.001	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	25.00 ± 45.23	2.193	0.109
***Proales* sp.**	14.29 ± 52.45	0.00 ± 0.00	6.921***	0.012	0.00 ± 0.00	16.67 ± 57.74	0.00 ± 0.00	16.67 ± 57.74	0.638	0.595
Brachionus dimitiatus	14.29 ± 59.09	0.00 ± 0.00	5.065*	0.029	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	33.33 ± 88.76	0.960	0.424
Trichocerca rattneri	10.71 ± 41.63	0.00 ± 0.00	5.952*	0.019	0.00 ± 0.00	16.67 ± 57.74	8.33 ± 28.87	0.00 ± 0.00	0.820	0.493
Brachionus quadridentatus	3.57 ± 18.90	0.00 ± 0.00	2.906	0.095	0.00 ± 0.00	0.00 ± 0.00	8.33 ± 28.87	0.00 ± 0.00	0.820	0.493
Asplanchna brightwelli	3.70 ± 19.25	0.00 ± 0.00	3.186	0.081	8.33±28.87	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.378	0.268
Asplanchna priodonta	21.42 ± 95.67	0.00 ± 0.00	4.191*	0.046	8.33±28.87	0.00 ± 0.00	0.00 ± 0.00	41.67 ± 144.34	0.847	0.476
Arganotholca faliaea	18.52 ± 68.15	0.00 ± 0.00	6.833***	0.012	25.00 ± 86.60	0.00 ± 0.00	0.00 ± 0.00	16.67 ± 57.74	0.931	0.437
Lecane leontina	14.82 ± 53.38	0.00 ± 0.00	7.240***	0.010	16.67±57.74	16.67 ± 57.74	0.00 ± 0.00	0.00 ± 0.00	0.960	0.424
Testudinella berzinzi	3.57 ± 18.90	0.00 ± 0.00	3.062	0.087	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	8.33 ± 28.87	0.960	0.424
Ephiphanes brachionus	3.57 ± 18.90	0.00 ± 0.00	3.062	0.087	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	8.33 ± 28.87	0.960	0.424
Conochilus unicornis	11.11 ± 42.37	15.00 ± 67.08	0.311	0.580	0.00 ± 0.00	0.00 ± 0.00	8.33 ± 28.87	45.45 ± 103.57	0.820	0.493
***Spirostomium* sp.**	3.57 ± 18.90	0.00 ± 0.00	2.906	0.095	0.00 ± 0.00	8.33±28.87	0.00 ± 0.00	0.00 ± 0.00	0.970	0.415
***Loxodes* sp.**	3.57 ± 18.90	0.00 ± 0.00	3.062	0.087	0.00 ± 0.00	0.00 ± 0.00	8.33 ± 28.87	0.00 ± 0.00	0.820	0.493
***Coleps* sp.**	32.14 ± 86.30	21.05 ± 63.06	0.963	0.332	72.73 ± 127.21	0.00 ± 0.00	25.00 ± 62.16	16.67 ± 57.74	3.719*	0.022
Ceratopogonid larva	7.41 ± 26.69	10.00 ± 30. 78	0.380	0.541	9.09 ± 30.15	8.33±28.87	8.33 ± 28.87	8.33 ± 28.87	0.023	0.995
***Ostracoda* sp.**	7.41 ± 26.69	5.00 ± 22.36	0.435	0.513	25.00 ± 45.23	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.307*	0.033
Centropyxis aculeate	7.41 ± 38.49	0.00 ± 0.00	3.186	0.081	0.00 ± 0.00	16.67 ± 57.74	0.00 ± 0.00	0.00 ± 0.00	0.960	0.424
Arcella vulgaris	15.39 ± 54.35	5.26 ± 22.94	2.652	0.111	45.45 ± 82.02	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.307*	0.033
Amoeba radiata	14.29 ± 44.84	15.00 ± 15.08	0.046	0.832	41.67 ± 99.62	16.67 ± 38.93	0.00 ± 0.00	0.00 ± 0.00	1.018	0.398

* significant; *** highly significant; **** very highly significant

4. Discussion

The discharge from carwash effluent, as revealed by the concentration of essential nutrients (nitrate, sulphate, and phosphate) and the slight acidic range of the pH (5.80–7.55) recorded, could lead to increase in the primary productivity of water bodies, while the acidic pH recorded upstream could be attributed to sewage discharged at this station from the catchment area of the river containing faecal matter and agricultural waste. This also accounted for the comparatively high turbidity recorded upstream though turbidity was above the recommended values at all sampled stations [22], whereas the high turbidity values recorded at the discharge points have been attributed to the colour of detergent and oil/grease in the waste-water [23].

The gradual increase in apparent colour from discharge points confirmed the alterations of the natural colour of water bodies by inflows [24], establishing the fact that the colour of water bodies is not dependent on its natural components only but on the anthropogenic activities within its catchment area. Moreover, the highly significant difference ($p < 0.01$) in the apparent colour between the investigated stations, which separated upstream from all other stations, is a reflection of the carwash effluent effect on the colour of Odo Ebo River.

The effect of the effluent as recorded in the higher mean values of major ions (phosphate, sulphate, and nitrate) has been reported by researchers such as Sablayrolles et al. (2010) [25], Aisling et al. (2011) [26], Adeyemi-Ale (2014) [27], and Danha et al. (2014) [12]. They attributed the increase in loads of these major ions to the hydrocarbon components of detergents being used at the carwash bay, thus to organic pollution. The high level of COD and electrical conductivity at the effluent receiving points were also indicators of high ionic concentration resulting from the release of ions into the river via the effluents [28]. The pronounced mean concentration of sulphate, most especially during the rainy season, confirms its solubility and persistency in water [29, 30]. Furthermore, sulphate ions as contained in linear alkylbenzene sulphonates (LAS) are very important constituents of detergents being used in the carwash industry, as reported by Sablayrolles et al. (2010) [25].

The higher mean values of dissolved oxygen, BOD_5, turbidity, and true colour recorded upstream and downstream were reflections of higher biological productivity and organic detritus at these stations as compared to discharge points. This was further confirmed by the abundance of *Coleps* sp. at these stations, which is a good indicator of organic detritus and is often less abundant in polluted water than recorded from the effluent receiving points.

The zooplankton abundance was equally more upstream and downstream than the abundance recorded at the discharge points. A decrease of 12% in zooplankton abundance was recorded at the 1st discharge point, which was further reduced to 44%

at the 2nd discharge point as compared to the abundance recorded upstream. This later increased to 109% downstream as against the recorded abundance at the 2nd discharge point. This increase in zooplankton abundance downstream coupled with species richness could be attributed to the eutrophication effect of the carwash effluent, while the nine species recorded specifically from the discharge points were well-known eutrophic species [31].

The effect of the effluent was also revealed in the temporal abundance of the zooplankton with 11 out of the 31 species recorded having highly significant seasonal variation, 9 of which were more abundant in the rainy season. Moreover, zooplankton abundance during the rainy season was twice that of the dry season, which has been attributed to nutrient influx with run-off [32]. Adeniyi and Adedeji (2007) [33] also attributed the qualitative richness to the mixing effects of the run-off, which usually frees organisms from river beds and littoral vegetation.

In conclusion, the study revealed the eutrophic effects of carwash effluent on water bodies through the increase in major nutrient ions at the discharge points, especially phosphate and nitrate ions, leading to reduction in dissolved oxygen and zooplankton abundance, change in apparent water colour, and increase in COD. Therefore, carwash effluents are a potential risk to the receiving water body; hence, the government needs to put measures in place to check the indiscriminate siting of carwash bays by river banks for environmental protection.

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Conflict of interest

There is no conflict of interest as regards the publication of this research finding.

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The case study of 10 historical gardens in the Banat region

Noémi Melitta HEGEDŰS

Doctoral School of Technical University of Cluj-Napoca, e-mail: hegedusnoemi@yahoo.ro

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Abstract. The object of the research is developed around the historical gardens belonging to certain historical monuments, more precisely in relation to the palaces and manors of aristocratic families from the Banat area. These gardens are selected according to certain criteria that preserve physical and documentary stylistic and memorial values. The aim of the research is the studying of a frequently met phenomenon both as specialists in the field and as simple citizens, that is, the loss of values of a building and its surroundings, which at the time of their construction had a special historical and architectural value, but with the passing of time they lost some of these values due to political, social, and cultural changes. The gardens, manors, and palaces are testimonies of the past. They present a private and urban lifestyle at a certain social, cultural, and architectural level. This paper has the purpose of investigating these still existing landscape arrangements as well as the main factors that lead to their transformation, their problematics being discussed from its historical, architectural, and social-cultural perspective.

Keywords: historical value, research, authenticity, monument

1. Introduction

A recurring phenomenon from the beginning of humankind up to the present is man's will to play the role of the almighty, thus changing and perfecting the environment, which is by definition created perfect and does not accept any man-made improvement that would last forever.

Natural environment works differently – this being untouched, persists and develops naturally, according to its own rules. Gardens created by man, organized and reorganized, are realized after a certain human rule, a conception, vision of the epoch, of the given period's fashion that would persist only up to a certain limit, when it reaches degradation due to natural phenomena. The passing of time says its words and the fashion of landscape arrangements change together with the passing of time, similarly to the cases studied within the frames of this paper.

The object of the research is developed around the historical gardens belonging to certain historical monuments, more precisely in relation to the palaces and manors of aristocratic families from the Banat area.

The understanding of the environment, time as well as the historical and social coordinates of the periods of theoretical and practical patrimonial accumulations represented a great interest to this research; thus, the present paper had an aim to investigate these still existing landscape arrangements as well as the main factors that lead to their transformation.

The transformation sequences of these historical gardens have been studied in comparison with their actual state, the problematics being treated both from historical perspective and under social-cultural aspects.

The realized inventory is addressed primarily to architects, landscape artists, and urbanists, those who implement development and rehabilitation projects of these monuments, but also to theorists. It is addressed to mayor's offices, prefectures, county councils, and ministries. Thus, with the help of the accumulated information, of the obtained historical documents and cadastral maps, specialists in the domain are offered an image of the original historical park that also offers the possibility to partially restore the former historical garden on the site that is currently available, this way being able to contribute to a positive development of attitude towards historical gardens and eventually towards the historical monument it belongs to.

The object of the study was the analysis of the actual state of the historical gardens of the Banat region with the help of a detailed presentation of case studies, where the actual situation of the historical gardens and their evolution over time have been documented. All case studies have been analysed and researched according to the adopted methodology and through the description of all activities that had contributed to the alteration of the original situation after the moment of their construction. Their presentation and assessment from an architectural and landscape art standpoint could be realized with the aid of on-site research and the comparison of their state to the documents identified with archive research [1] and the studied historical maps [2].

2. Materials and methods

The identified case studies have proved to be unitary as far as the chosen project and the research periods are concerned, which is delimited between the 17th and the 21st centuries, covering the territories between the Oriental Carpathians and the Crişana region. The research has been realized concerning architectural complexes already classified as historical monuments [3].

We have visited over 40 sites considered valuable and as having a historical past, outstanding architecture, or landscape art according to the studied documents issued at the moment of their construction [4].

From all the researched sites, I have chosen 33 manors and gardens, three manors being situated in Caraş Severin County, fifteen in Timiş County, and thirteen in Arad County, followed by 10 gardens classified as historical monuments that were to be studied and presented in detail.

Figure 1. Historical gardens classified as historical monuments, studied in detail
1. Banloc – Timiş: park of the Banloc Manor, 2. Lovrin – Timiş: park of the Lipthay Manor, 3. Bulci – Arad: Mocioni Castle Park, 4. Căpâlnaş – Arad: Teleki Castle Park, 5. Fântânele – Arad: Kövér-Appel Castle Park, 6. Macea – Arad: park of the Cernovici-Macea Castle, 7. Mocrea – Arad: Solymosy Castle Park, 8. Odvoş – Arad: park of the Konopi Castle, 9. Petriş – Arad: park of the Salbek Castle

The majority of these manors and castles are left in an advanced state of degradation, being deserted; however, some of them are used to house public functions, rarely in private use.

The gardens of these constructions classified as historical monuments have disappeared in most cases without any trace of landscape arrangement specific to the original state. In the case of the gardens classified as historical monuments, the

only remaining proof that could be considered as a guiding reference point are elements of tall vegetation, rare species of trees that survived in most of the gardens. As far as low or medium vegetation or landscape arrangement elements are concerned, in most cases, they are unidentifiable. These gardens have acquired their status of historical monuments primarily due to the monument buildings they belong to or to personalities playing an important role in erecting and arranging the given castle-garden complex as well as due to their artistic composition and certain structural elements still existing on site, proving the original landscape character of the park.

In the classification and description of the selected historical gardens, we have adopted an ample methodology, consisting of the realization of a short history of the studied aristocratic domains and families, realized a brief localization of the geographic situation of the locality[5] as well as its short historical presentation, described the local terrain and the placement of the major elements on the site, studied the accessibility of the site and construction followed by the description of the residence and its relation to the exterior arrangements, and finally focused on the exterior arrangements.

All the case studies realized on historical gardens classified as historical monuments have been analysed and researched according to the mentioned criteria all along their evolution, from their creation up to the present. Their presentation and assessment from an architectural and landscape art standpoint could be realized with the aid of on-site research and their comparison to the documents discovered with the help of archive research, the recovered contemporary images [6], and the studied historical maps.

3. Results and discussions

As a result of our research, we can establish that in the majority of the studied cases there have not been major alterations of the historical constructed bases. The basic construction remains the castle, presented in its identical form along the time, without suffering additions and extensions of the original, contemporary layout and volume image. Minor modifications of the constructed base can be observed studying historical maps, where we can identify the disappearance of secondary constructions and in some cases the appearance of other annexed constructions.

The state of these castles varies from case to case. The castles that have a constant function, such as the case of the castles from Căpâlnaş, Mocrea [7], Macea [8], and Şofronea, and thus the maintenance of these castles is permanent. The rest of the castles have no function in the present, some of them beinge even in an advanced state of degradation such as the castles of Bulci [9] and Odvoş. The accessibility of these castles being relative from case to case, some of them are

accessible due to the functions they serve but in the majority of the cases due to their state of abandonment.

Along the historical periods, only the dimensionally smaller establishments, such as the manors of Lovrin [10], and even Căpâlnaș, do not suffer modifications to their original extent of the domain. In the rest of the visited cases, the establishments suffer major modifications in comparison to the original layout, existent at the appearance of the castle and garden as opposed to their present-day layout.

Few gardens present traces of the contemporary historical gardens, their footprints having disappeared due to the events of historical periods and the transfer of these domains into various ownerships, eventually ending up in the possession of the state, which significantly neglected the state of these castles and gardens. This way, in addition to the advanced state of degradation of the castles, we can talk about the disappearance of the historical gardens, remaining only a few old trees that would stand for proof of the abundant vegetation once existing on the establishment. In most cases, only the tall vegetation has survived, certainly even this being in a wild and unmaintained state. Medium and low vegetation that would prove the historical footprint of the garden can no longer be found on these establishments. In some cases, existing alleys or traces of alleys and pathways prove the existence of former circulation routes, these being visible mostly in the case of castles having a constant function along the time and still having a specific function today such as the case of the castles from Căpâlnaș and Mocrea, both of them functioning today as psychiatry hospitals. This way, due to these existing functional establishments and constructions, the destruction of these gardens proved to be a slower one, and so some specific elements of the historical gardens are still visible today.

The complete visitation of the establishments was impossible in most cases since, although some of them are functional and the garden still serves its interior function as well, these are not entirely maintained, certain areas being inaccessible because of the wild vegetation that does not allow full access and the complete visitation of the domain.

In a few establishments, we can witness certain modifications and new completions of garden rearrangement, of contemporary nature appearing next to the original-historical arrangements that have been undertaken mostly due to the necessities of the castle's interior functional roles extending towards the exterior, rather than out of the will to realize an impressive landscape arrangement with the intention of making it become historical in time, such as in the case of Căpâlnaș, where this impact does not seem abusive, the alteration of its vegetation being minimal. However, in the case of the Şofronea establishment, the functioning of a thermal spa in the former historical garden has led to the deforestation of a significant portion of the original historical garden.

Few of the original valuable architectural ornamental objects can be found, these having been destroyed during the wars and due to the destructions suffered with the passing of time. There have been found some original flower supports on the establishments of Căpâlnaş and Bulci as well as some examples of artesian fountains specific to the era, such as the case of Banloc [11] and Petriş, these being completed by delimitation elements of the establishments with the aid of specific portals such as the monumental portals in the case of the Banloc Castle.

Figure 2. Contemporary postcards and images of the studied historical gardens of the Banat region

The studied castles and the adjacent gardens have been built approximately in the same historical period and are characteristic of the neo-classicist style that manifests itself in the case of the garden arrangements as well. However, in the case of the establishments with larger dimensions, next to the neo-classicist style present in the immediate vicinity of the castle, we can find extensions of the park towards the landscape style such as the case of the parks from Bulci, Petriş [12], and Odvoş.

A special case is the garden of the Csekonics Castle from Macea, which is under continuous maintenance due to its function as a dendrological park. The establishment does not keep its original extent, this increasing and then decreasing in surface, while, due to these layout modifications, a periodical rearrangement of the park can be identified as well along its history. Thus, the attribution of a certain

arrangement, studied on historical cadastral maps, the state of the original historical garden is difficult to define since this park had been in a continuous evolution along time, and it reached the status of a dendrological park only in the second half of the 20th century [13].

4. Conclusions

Any planning or intervention regarding the restoration of historical gardens must be preceded by historical research. The monumental value of a site is given by an ensemble of different historical layers that would help us understand the message of the garden. New interventions should consist of additions that continuously improve the value of the architectural complex and that permit the authentic restoration of the park in the light of new possible sets of information. Thus, during the revitalization intervention, decisions concerning the stylistic period to which it is possible/permitted to return to as far as the garden (or part of the garden) is concerned shall always be made based on the available information, considering the principle according to which it the destruction of any element dating from various historical periods in favour of presenting a different era is not permitted.

The historical gardens researched within this study present currently available historical documents that prove the existence and evolution of these gardens, thus their restoration not presenting any problems for the specialists in the area. Concerning the studied ten historical gardens of the Banat region within this research, in most cases, we have found significant and veracious documents, out of which especially the detailed documentation and preservation of these values in the cases of the castles from Banloc, Bulci, Macea, and even in the case of the Căpâlnaș Castle are worth mentioning. All these examples include cartographic information, contemporary images, memories, and descriptions that present a clear picture of the contemporary garden.

Flexibility is the key for the conservation of historical gardens, and it is the only realistic answer to the inevitable forces of change. For the conservation specialists of the gardens, it is essential to understand the types of the gardens and their behaviour, which is significant in each case, be it a historical, botanical, artistic, or any other standpoint, as the gardens evolve in time, with different owners who introduce their own personal ideas, both formal and social, which modify the aspect of the garden [14].

This study presents itself with an open topic, free for ulterior completions both at the level of the researched and presented documents and from the standpoint of the problematics of authenticity, followed by theories and possibilities of restoration, rebuilding, and conservation of these historical gardens.

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The third topographical map made between 1869 and 1887 (in German: Franzisco-Josephinische Landesaufnahme or Dritte Landesaufnahme) "Franciscan Josephine Topographical Map".
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Technical Note

Researches on the reliability of spraying machines in vineyards and orchards

Tibor RITTNER,[1] Ioan ȚENU,[1] Ovidiu MARIAN[2]

[1] Ion Ionescu de la Brad University of Agricultural Science and Veterinary Medicine, Iaşi, Romania, e-mail: tibor.rittner@autogrand.ro, itenu@uaiasi.ro

[2] Faculty of Agriculture, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, e-mail: ovidiu.marian@usamvcluj.ro

Abstract. The goal of the research was to determine the level of abrasion of different types of nozzles during different types of uses and at different pressure values.

The experiment assembly consists of an ATOM-300 carried sprayer, manufactured by S.C. TEHNOFAVORIT S.A. Bonţida-Cluj, and a stand for testing the distribution uniformity of the vineyard and orchard sprayers Herbst ED20-900, manufactured by Ernst Herbst Prüftechnik e. K. Hirschbach-Germany.

The 4 types of nozzles used were Lechler Ceramic 1.0 and 1.2; Lechler TR 80-30 and Lechler ITR 80-015 with air induction.

The measurements were made on a water pressure of 10 bar and 20 bar, and the testing period was equivalent with the duration of a campaign. The study below presents the variations of the debit measured in each type of nozzle according to the time and pressure.

Keywords: nozzle, atomizer, herbicide sprayer, vineyards

1. Introduction

The technical condition of atomizers in vineyards and orchards are greatly influenced by the pollution of the soil and the environment. These conditions induce loss of the treating solution and overrun of the application rules per hectare. The exact identification of nozzle wear stages allows us to have a knowledge of the maximum usage time when all application conditions are still met. Numerous scientific studies have contributed to the right choice of materials, the construction of nozzles, and the development of their operation principle.

2. Materials and methods

The trial and experiment assembly consists of an ATOM-300 carried sprayer, manufactured by S.C. TEHNOFAVORIT S.A. Bonţida-Cluj, and a stand for testing the distribution uniformity of the vineyard and orchard sprayers Herbst ED20-900, manufactured by Ernst Herbst Prüftechnik e. K. Hirschbach-Germany.

Figure 1. Irrigation machines

Table 1. The elements composing the statistical observation collection process

No	Name – producer	Testing pressure	Scattering head – codification	Observation period (min)	No of observations performed
1	Lechler Ceramics 1.2	10 BAR	LC_1,2_10BAR	15,873	42
2	Lechler TR 80-30	10 BAR	L_TR 80-30_10BAR	22,978	69
3	Lechler Ceramics 1.0	10 BAR	LC_1.0_10BAR	7,036	11
4	Lechler ITR 80-015	10 BAR	L_ITR 80-015_10BAR	8,795	16
5	Lechler ITR 80-015	20 BAR	L_ITR 80-015_20BAR	8,544	20
6	Lechler 1.0	20 BAR	L_ 1,0_ 20BAR	5,464	21
7	Lechler 1.0	20 BAR	L_ 1,0_ 20BAR	6,000	37
8	Lechler ITR 80-015	20 BAR	L_ITR 80-015_20 BAR	6,003	37

Note: the statistical interpretation of the results regarding the measurement of the flow released by the 4 types of nozzles, tested under a pressure parameter over a time range called observation period.

The purpose of the statistical processing is that of evaluating the studied phenomenon on the time axis, by means of a representation of the absolute values obtained through the measurement, as well as determining the phenomenon's proportions. For this purpose, classical instruments have been used (mediums, indices) as well as processing in order to obtain derivative statistical data (medium and index differences) and their graphic representation. For the drawing of the conclusions, we have tried to observe the basic phenomenon (flow variation depending on the time), the disrupting phenomena, along with the determination of their systematic or random determination. The partial conclusions are connected between them, creating a whole at the end.

Due to the fact that the tables and the figure presented in this chapter are prepared by the author of this paper, upon their presentation, this source should be implicitly considered, without explicitly mentioning him in this chapter each time.

Work hypotheses

- the series built based on the measured data creates *a chronological series of moments*;
- it is considered that the nozzles tested simultaneously (12 pieces) are of the same type, having the same manufacturing parameters;
- the distribution pipe is considered as having a constant section during the observation period (no deposits occur);
- the liquid circulating within the spraying system is considered as having the same physical and chemical parameters during the observation period;
- a constant liquid pressure is considered during the observation period;
- the work equation $Q = S * V$ is considered, where S – the nozzle section, V – the speed of the liquid;
- liquid viscosity is considered to be constant during the observation period;
- a measurement range of approximately 30s is considered, by means of which the flow sprayed by a nozzle is established;
- the statistical data is collected simultaneously from the 12 nozzles analysed (6 on the right and 6 on the left);
- the environmental temperature does not have significant variations during the observation period;
- the observation period for each chronological series unfolds for at least 5 days and up to 16 days.

Statistical processing included in the analysis

- the measured variable has the following characteristics:
  - is quantitative – the flow of the scattering nozzles (litre/min),
  - is continuous – it can take any rational value;
- the flow average is calculated for the 6 nozzles on the right and on the left respectively, in each observation moment – it is marked as Medie DR (Right Average) and Medie ST (Left Average);
- the difference between the LA and the RA is calculated in each moment of observation – it is marked as Dif Medie ST/DR (Average difference left/right – Av. Dif. L/R);
- the flow average is calculated for each nozzle during the observation period;
- the observation period is calculated both in minutes and in hours. The unit of measurement for the time axis is the minute.
- the index of the fixed-base modification is calculated. The first observation is considered to be the fixed-base. This index is calculated not only for each information collected but for the calculated averages, as well.

The index of the fixed-base modification represents the proportion of the level registered during a certain period as compared to the level considered to be the basis for comparison.

$$I_{i/1} = Y_i / Y_1$$

- the rhythm of the fixed-base dynamics is calculated. The first observation is considered to be the fixed-base. This index is calculated not only for each collected information but for the calculated averages, as well.

The dynamics index relatively expresses the increase or the decrease achieved during each period as compared to the level considered to be the basis for comparison.

$$R_{i/1} = (Y_i - Y_1) / Y_1$$

Table 2. The flow averages for each set of the 12 nozzles tested

Scattering head	Left Flow 1 l/min	Left Flow 2 l/min	Left Flow 3 l/min	Left Flow 4 l/min	Left Flow 5 l/min	Left Flow 6 l/min	Right Flow 1 l/min	Right Flow 2 l/min	Right Flow 3 l/min	Right Flow 4 l/min	Right Flow 5 l/min	Right Flow 6 l/min
LC_1.0_10Bar	0.706977	0.601365	0.653865	0.647241	0.612631	0.698492	0.636846	0.663252	0.605831	0.622062	0.639459	0.638630
LC_1,2_10BAR	1.307134	1.283532	1.188960	1.393289	1.230324	1.242091	1.230345	1.328430	1.295547	1.260897	1.295228	1.266359
L_TR 80-30_10BAR	0.698741	0.712719	0.679419	0.676859	0.679824	0.712216	0.687547	0.705964	0.697420	0.701139	0.713367	0.666631
L_ITR 80-015_10BAR	0.899795	0.855730	0.872197	0.833251	0.843524	0.844013	0.884155	0.862268	0.846560	0.872669	0.864369	0.854336
L_ITR 80-015_20BAR	1.252275	1.200043	1.213929	1.171041	1.120641	1.126362	1.114366	1.208063	1.190978	1.222932	1.219810	1.204761
L_ 1,0_ 20BAR	1.736204	1.604845	1.339802	1.698188	1.694300	1.527014	1.673509	1.697086	1.316252	1.601409	1.622324	1.692860
L_ 1,0_ 20BAR_BIS	1.546021	1.551065	1.498367	1.377175	1.638868	1.638333	1.546021	1.551065	1.498367	1.377175	1.638868	1.638333
L_ITR 80-015_20BAR_BIS	1.073176	1.076875	1.061221	1.102604	1.062743	1.076067	1.073176	1.076875	1.061221	1.102604	1.062743	1.076067

Based on the data above, the following graphic representation is created:

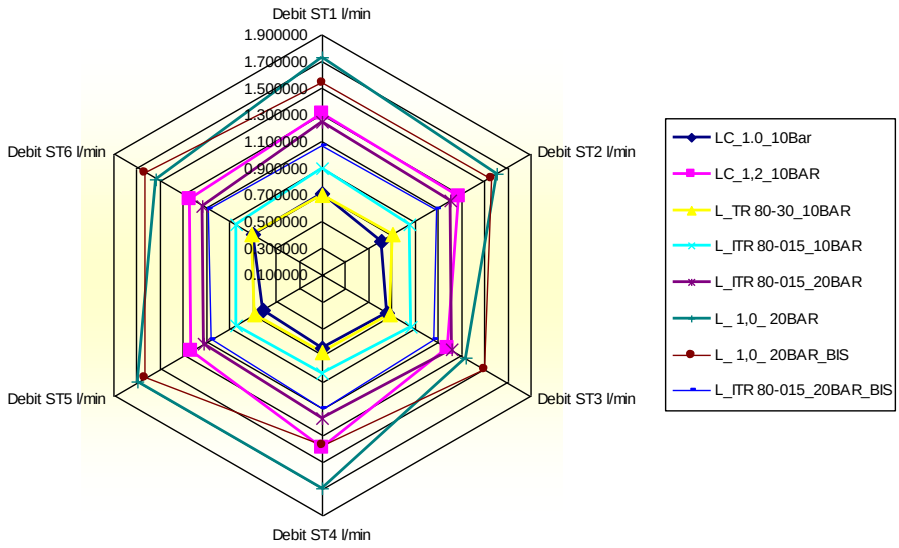

Figure 2. Representation of the average flows

The average flows are represented during the observation period for each 6 LEFT nozzles and 6 RIGHT nozzles, corresponding with the 8 measurements conducted with the 4 nozzle types subject to the 2 testing pressures (10 and 20 ba).

A concentric layout can be noticed, corresponding with the pressure which the nozzle is supplied with.

3. Conclusions

1. Given the initial hypotheses:
   - the series built based on the measured data creates a chronological series of moments;
   - the simultaneously tested nozzles taken into consideration (12 nozzles) are of the same type, having the same manufacturing parameters;
   - the distribution pipe is considered as having a constant section during the observation period (no deposits occur);
   - it is considered that the liquid circulating within the spraying system has the same physical and chemical parameters during the observation period;
   - the pressure of the liquid is considered to be constant during the observation period;

- the work equation is considered to be Q = S·V, where: S – nozzle section, V – liquid speed;
- it is considered that the viscosity of the liquid is constant during the observation period;
- it is considered that the measurement range is approximately 30 s, by means of which the flow sprayed by a nozzle is established;
- statistical data is collected simultaneously with those from the 12 nozzles analysed (6 right and 6 left);
- the environmental temperature does not vary significantly during the observation period;
- the observation period for each chronological series unfolds for at least 5 days and up to 16 days.

2. The statistical data – the measurements – are values of high-precision flows. The measurements have been conducted on 4 types of nozzles, in 3 different conditions, represented by means of the "work pressure" variable, 7 different situations resulting from such measurements. After analysing the data, we were able to observe the following:

- in the Lechler Ceramics 1.0 nozzle, with a 10-bar pressure swirl element, a slight increase of the flow was noticed during the determination period; the increase variation was linear, but the behaviour of the two average values was slightly different on the two spraying ramps. This increase was owing to the wear of the ceramic plate during the run-in phase, followed by a decrease of this trend, and the nozzle flow became almost constant.
- in Ceramic 1.2 nozzle, with a 10-bar pressure swirl element, the evolution featured a slight decrease trend, then a uniform increase, and then reaching a stability afterwards.

The two averages, Right and Left, feature the same evolution, and the trends are expressed by means of the same 1st-degree equation; therefore, we may say that the 12-piece nozzles have a homogeneous behaviour.

3. In the special TR 80-030 and ITR 80-015 nozzles, we have found that the evolution was generally a decreasing one, with slight increases in the beginning, but the trend is a flow decrease one.

The nozzle behaviour on the two ramps is symmetrical, reacting in the same manner upon external shocks in the case of external perturbations.

The two averages, Right and Left, feature the same evolution, and the modification trends are expressed by means of the same 1st-degree equation; thus, we can conclude that the 12-piece nozzles have a homogeneous behaviour.

4. The evolution of the difference between the Averages of the fixed-base index feature a constant decrease, but, at the same time, the existence of an external

factor can be noticed, which influences this evolution. This factor, in our case, can be the water homogeneity modification, the sliding of the driving belt, the water heating, or calcification deposits.

5. I believe that during the experiments the 4 types of nozzles have passed through run-in and have been well operating long enough. A slight flow decrease has been noticed, caused by the deposits inside the nozzles, which made the liquid passage section smaller, but it did not reach that level of deterioration for exploitation reasons.

6. I believe that by means of this measurement session I have managed to observe and analyse those stages in the life of the product where it calibrates and behaves in a constant manner. The flow variation, in both the positive and the negative direction, does not influence the quality of the treatment work and does not generate spraying-substance additional loss or quantitative insufficiency.

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Sapientia Hungarian University of Transylvania
RO 400112 Cluj-Napoca, Romania
Str. Matei Corvin nr. 4.
E-mail: acta-agrenv@acta.sapientia.ro

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