Anthropic Impact on Soil of the Chamaeropaie in Tlemcen Region (Western Algeria)

Brahimi Naima[1] and Hasnaoui Okkacha[1,2]

[1]Laboratoire d'Ecologie et gestion des écosystèmes naturels. Université de Tlemcen.-Tlemcen-Algérie.
[2]Faculté des sciences –Département de Biologie. Université Dr Tahar Mouley- Saida.

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Powerful environmental agent, man alters ecosystems and environments. Since the Neolithic he went through domestication, artificialization of the soil, construction of terraces on slopes, urbanization and overgrazing. The intervention of man and his cattle impacted unevenly media components of the environment but the most visible elements are biotic and among them the soil. This study reveals the extent of this intervention by the disturbance of the soil (compaction, erosion). The determination of the packed soils surface (in m^2) and their weight (in kg) is based on using the profile method which consists in metric measurements on 10 points located in a path created by man and his flock on a distance of 100 m. The interpretation of results by the Anova 1 and the PCA has clarified the affinities that exist between, on one hand, the compacted soils of the different stations, and, on the other hand to highlight the anthropozoogenic impact on the soil of Chamaeropaie.

Keywords: Chamaeropaie, Compaction, Anthropic Action, Statistical Study, Tlemcen Mounts.

Throughout its history, an ecological system undergoes a variety of disturbances at different spatial and temporal scales. This set, called "disturbance regime," is characterized by the nature of phenomena (fire, grazing, plowing, etc.), their spatiotemporal frequencies, their intensity and their respective sizes[1]. Each component of the disturbance regime behaves in a clearly manner on communities and populations. The disturbance effect can also vary according to their dates of occurrence, their location, their predictability, and also to the local and regional disturbances history[2,3].

* To whom all correspondence should be addressed.
E-mail: brahiminaima26@yahoo.fr

Grazing, although ancestral, occurs with a frequency and an intensity which varies throughout the year, and between successive years. Thus, the vegetation does not suffer all the time the same pressures, it is than unpredictable and it affects the structure of plant communities, causing their partial destruction (reduction of biomass). When grazing pressure becomes too great and the harvesting of resources exceeds their renewal, grazing becomes harmful[4].

For rangelands, the surface conditions affected by grazing[5-9]. The physical effects of the grazing animal's hooves can cause loss or mechanical damage to the vegetation and changes to the soil surface condition[10-12]. The hoof, of the animal in movement, exerts forces on the soil surface in three directions: a vertical component of the top-down (weight), a sagittal component from front to rear (propulsion) or conversely (braking) and a lateral component of the body towards the outside (balance). The amplitudes of these forces vary according to members, front or rear, and the nature of the movement (walking, trotting or cantering)[13]. This shows that an animal in motion can have two simultaneous actions on the soil: surface compaction and erosion of soil.

Several results are available throughout the world and show that the impact of grazing on the soil surface condition varies depending on the ecosystem characteristics (soil, climate, vegetation) and the type, intensity, timing and duration of grazing. In particular, the importance of the effects of trampling on the soil varies depending on animal charge [14,15], soil type (texture, organic matter content and moisture)[16,17], seasonal weather conditions[18] and the vegetation type [19,6].

The works of Hasnaoui[20], Benabadji *et al*[21], Merzouk[22] and Hachemi[23] show the impact of grazing on scrublands and steppes of Tlemcen region. The ecosystem of the west Algerian part undergoes an important stocking, and that is causing the soil structure disturbance.

Overgrazing from inappropriate management of pastoralism, mainly sheep and goat, upsets the fragility and potential of the natural resources. Grazing leads to soil compaction and erosion of its upper horizons.

The soils are mostly made up of little evolved soils, their surface particles are easily destabilized; they move on short distance and accumulate creating an effect of arenization.

Overgrazing also causes the plant cover loss and the floral heritage erosion and causes the loss of characteristic species perfectly adapted to the ecological factors by the transformation of the facies.

The Tlemcen scrublands region consists mainly of *Chamaerops humilis* (*C.h*), *Calycotome intermedia*, *Asparagus acutifolius*, etc. These ecosystems are used by farmers as grazing land. According to Hasnaoui[20], (*C.h*) dominated ecosystems are called Chamaeropaie; and they are generally rangelands.

This research aims to identify the effect that can cause livestock on soil structure of the west Algerian scrublands. This work, in which we are the forerunners, will help us identify the solutions to take for a sustainable development.

To approach the impact of the pastoral charge in the ecosystem dynamics is of great importance. In order to deepen the knowledge on the Chamaeropaie behavior, in view of anthropogenic pressures and to provide elements for solutions that help conserve natural resources, we conducted in-situ measurements on the behavior of soil undergoing the often too strong herd charge.

Anthropogenic impacts, related to the overgrazing, are shown by the trampling of the herbaceous layer, compaction and soil erosion. The latter can appear with the departure of soil fines due to the crumbling of the soil surface structure by the animals' hooves.

The main objective of this study was to quantify soil compaction after pressures of anthropogenic order primarily related to pastoral overloads. To determine the impact of livestock on the soil behavior, sites parameters were measured and statistically processed.

MATERIALS AND METHODS

Geographical location and description of the study stations

The study focused on quantifying the soils compacted by animals. Field measurements were performed in December 2015.

Six Chamaeropaies locations were selected for this work (Table 1). They are characterized by an altitude ranging between 710m and 1180m, vegetation composed mainly of (*C.h*), *Juniperus oxycedrus*, *Stipa tenacissima*, *Calycotome intermedia*, *Amepelodesma mauritanica*, *Thymus ciliatus*, *Asparagus acutifolius*, *Urginea maritima*, *Asphodelus microcarpus*, and a mediterranean climate.

They are usually covered by a large herd consisting of cattle, sheep and goats (Table 2).

Quantification of soil compacted

To determine the occurred soil changes, we follow an experimental protocol based on the profile method. The latter is to draw on the ground, using a marker, the limit of the path created by the herds in which we have a100 m length and on which we took 10 measurements (10 m spaced).

Parameters measured (photo.1):

-Major base (B) between two points of the line (in m)

Table 1. Location of study sites (Wilaya of Tlemcen)

Location	City/ County	Latitude	Longitude	Altitude (m)	Bioclimatic level	Main species	Slope
FRAWNA	Terny	34°47'N	01°24'W	1180	Semi -arid	(*C.h*) , *Ampelodesma mauritanica, Ammoïdes verticillata, Calycotome intermedia*	10%
MAFROUCH	Mansourah	34°50'N	01°17'W	1170	Semi -arid	(*C.h*) , *Quercus ilex, Juniperus oxycedrus, Ammoïdes verticillata*	12%
BOUDJMIL	Beni Mester	34°52'N	01°23'W	820	Semi -arid	(*C.h*) , *Calycotome intermedia, Olea europea*	10%
OUCHBA	Chetouane	34°53'N	01° 15'W	710	Semi -arid	(*C.h*) , *Lavandula stoechas, Thymus ciliatus Urginea maritima, Asphodelus microcarpus, Calycotome intermedia*	15%
AIN FEZZA	Aïn Fezza	34°52'N	01°14'W	860	Semi -arid	(*C.h*) , *Ampelodesma mauritanica, Asparagus acutifolius, Ceratonia silica, Thymus ciliatus*	25%
OUED LAKHDAR	Oued Lahkdar	34°52'N	01°07'W	750	Semi -arid	(*C.h*) , *Juniperus oxycedrus, Stipa tenacissima, Calycotome intermedia,Olea europea, Ampelodesma mauritanica*	25%

- Minor Base (b) between two points (in m)
- Height compaction (B) (in m)

Statistical Study

It is based on Anova 1 and PCA methods. With Anova 1, the objective was to see the station effects on different measurements used and PCA enabled us to identify the relationship between observed parameters and to enhance the anthropozoogenic impact on the soil of Chamaeropaie.

Results and interpretations

Table 2. Livestock (heads) in the studied stations.

Station	Sheep	Cattle	Goats
FRAWNA	720	380	240
MAFROUCH	926	175	310
BOUDJMIL	409	350	83
OUCHBA	500-700	150	60
AIN FEZZA	5000	250	100
OUED LAKHDAR	4500	380	488

Source: Farm Subdivision, 2015.

The results obtained are shown in Tables 4, 5, 6, 7, 8 and 9. The processing of the results by Anova 1 with one factor using XLSTAT 2014 shows that the p-values for all the variables measured are lower than the threshold á = 0.05 (P_B = 0.0230; P_b = 0.0010; P_H = 0.0393; P_S = 0.0237; P_{MV} = 0.0237). These results significantly reject the equality of means. We can say than that the station is of a significant effect on the variability of different parameters from one site to another.

In table 3 we have the Pearson correlations matrix. The latter shows the linear correlations of the variables taken two by two. We note that some correlations are very strong (r = 0.7171 (S / H and Mv / H) r = 0.9210 (B / b) and r = 1.0000 (Mv / S)), others are of average (r = 0.5659 (S / B and Mv / B) and r = -0.5150 (b / H)) and others rather low (r = 0.2201 (Mv / b) and r = -0.1463 (H / B)).

The average projection of the variables (B, b, H, S, Mv) in the correlation circle (Fig.2) shows the superposition of two variables S and Mv (strong correlation) and they are best represented in the axis1.

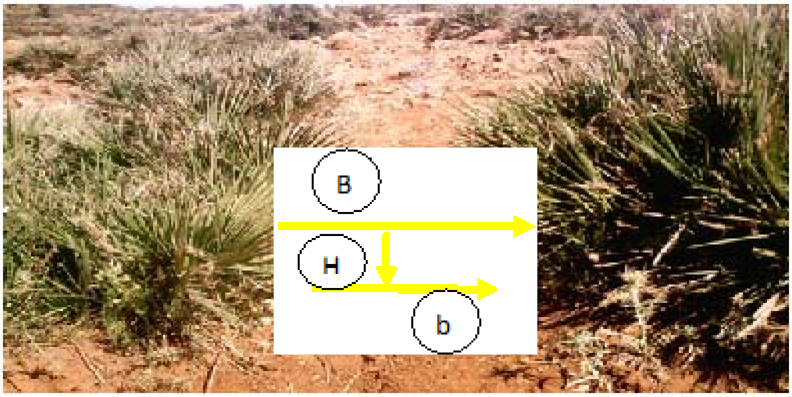

Fig. 1. Soil compacted and naked between two clumps of (*C.h*)

Table 3. Pearson correlations matrix.

Variables	B	b	H	S	Mv
B	1	0,9210	-0,1463	0,5659	0,5659
b	0,9210	1	-0,5150	0,2201	0,2201
H	-0,1463	-0,5150	1	0,7171	0,7171
S	0,5659	0,2201	0,7171	1	1,0000
Mv	0,5659	0,2201	0,7171	1,0000	1

* (S): compacted soil area
*(Mv): compacted soil density

Table 4. Différent parameters values - FRAWNA station

Station	FRAWNA (SF)					
Profile	Altitude	B (m)	b (m)	H (m)	S (m^2)	Mv(Kg/ml)
Obs1	1186	2,1	1,13	0,083	0,134	241,2
Obs 2	1185	1,11	0,55	0,123	0,102	183,6
Obs 3	1185	0,76	0,28	0,03	0,015	27
Obs 4	1186	1,12	0,52	0,1	0,068	122,4
Obs 5	1185	2,38	1,1	0,063	0,109	196,2
Obs 6	1182	0,83	0,25	0,1	0,054	97,2
Obs 7	1183	0,8	0,7	0,005	0,003	5,4
Obs 8	1184	1,74	0,83	0,03	0,038	68,4
Obs 9	1182	1,35	1,02	0,01	0,011	19,8
Obs 10	1190	0,6	0,49	0,015	0,008	14,4
Mean	1184,8	1,279	0,687	0,056	0,054	97,56

Table 5. Différent parameters values - MAFROUCH station

Station	MAFROUCH (SM)					
Profile	Altitude	B (m)	b (m)	H (m)	S (m2)	Mv(Kg/ml)
Obs 11	1150	1,52	0,57	0,073	0,076	136,8
Obs 12	1149	1,55	0,82	0,04	0,047	84,6
Obs 13	1149	0,8	0,65	0,005	0,003	5,4
Obs 14	1152	1,25	0,95	0,065	0,071	127,8
Obs 15	1152	1,13	0,57	0,075	0,063	113,4
Obs 16	1154	1,9	1,56	0,01	0,017	30,6
Obs 17	1151	1,08	0,78	0,04	0,037	66,6
Obs 18	1153	1,11	0,93	0,06	0,061	109,8
Obs 19	1153	1,95	1,1	0,015	0,022	39,6
Obs 20	1156	1,4	0,91	0,04	0,046	82,8
Mean	1191,9	1,369	0,884	0,042	0,044	79,74

Table 6. Différent parameters values - AIN FEZZA station

Station	AIN FEZZA (SA)					
Profile	Altitude	B (m)	b (m)	H (m)	S (m2)	Mv(Kg/ml)
Obs 21	846	2,46	1,56	0,075	0,15	270
Obs 22	840.5	2,06	1,16	0,075	0,12	216
Obs 23	837.5	0,79	0,66	0,035	0,025	45
Obs 24	834.5	1,62	1,17	0,025	0,034	61,2
Obs 25	833.2	1,82	1,25	0,065	0,099	178,2
Obs 26	834.5	1,97	1,46	0,03	0,051	91,8
Obs 27	834.7	2,65	1,77	0,05	0,11	198
Obs 28	836.3	1,15	0,62	0,025	0,022	39,6
Obs 29	836.3	2,33	2,13	0,02	0,044	79,2
Obs 30	839.6	2,1	1,6	0,07	0,129	232,2
Mean	837	1,895	1,338	0,047	0,078	141,1

Table 7. Différent parameters values - OUCHBA station

Station	OUCHBA (SO)					
Profile	Altitude	B (m)	b (m)	H (m)	S (m2)	Mv(Kg/ml)
Obs 31	710	1,2	0,95	0,033	0,035	63
Obs32	710.5	1,83	1,09	0,02	0,029	52,2
Obs 33	710.2	0,97	0,65	0,025	0,02	36
Obs 34	708	2,1	1,8	0,035	0,068	122,4
Obs 35	706.5	1,92	1,45	0,015	0,025	45
Obs 36	708.1	1,02	0,92	0,005	0,004	7,2
Obs 37	710	2,12	1,95	0,03	0,061	109,8
Obs 38	707	1,52	1,12	0,015	0,019	34,2
Obs 39	707.5	1,57	0,87	0,045	0,054	97,2
Obs 40	708.1	2,13	1,85	0,01	0,019	34,2
Mean	708	1,638	1,265	0,023	0,033	60,12

Table 8. Différent parameters values - OUED LAKHDAR station

Station	OUED LAKHDAR (SOL)					
Profile	Altitude	B (m)	b (m)	H (m)	S (m2)	Mv(Kg/ml)
Obs 41	755.1	1,45	0,9	0,06	0,07	126
Obs 42	752.7	1,22	0,62	0,025	0,023	41,4
Obs 43	752.3	2,37	1,52	0,045	0,087	156,6
Obs 44	751.9	1,46	0,88	0,05	0,058	104,4
Obs 45	753.9	0,93	0,43	0,05	0,034	61,2
Obs 46	755.1	1,26	0,66	0,055	0,052	93,6
Obs 47	752.9	0,94	0,52	0,045	0,032	57,6
Obs 48	745.8	1,82	1,12	0,075	0,11	198
Obs 49	749.6	1,17	0,77	0,06	0,058	104,4
Obs 50	757.3	0,84	0,47	0,075	0,049	88,2
Mean	752	1,346	0,789	0,054	0,057	103,1

Table 9. Différent parameters values - BOUDJMIL station

Station	BOUDJMIL (SB)					
Profile	Altitude	B (m)	b (m)	H (m)	S (m2)	Mv(Kg/ml)
Obs 51	808.3	0,95	0,43	0,07	0,048	86,4
Obs 52	807.2	0,8	0,52	0,005	0,003	5,4
Obs 53	806.8	1,08	0,6	0,05	0,042	75,6
Obs 54	807.3	1,2	1,05	0,003	0,003	5,4
Obs 55	808.6	1,55	0,92	0,045	0,055	99
Obs 56	807.2	1,3	1,02	0,005	0,005	9
Obs 57	804.5	1,07	0,95	0,015	0,015	27
Obs 58	804	1,95	1,68	0,015	0,027	48,6
Obs 59	805.5	1,25	0,85	0,05	0,052	93,6
Obs 60	807.5	1,2	0,87	0,045	0,046	82,8
Mean	806	1,235	0,889	0,03	0,03	53,28

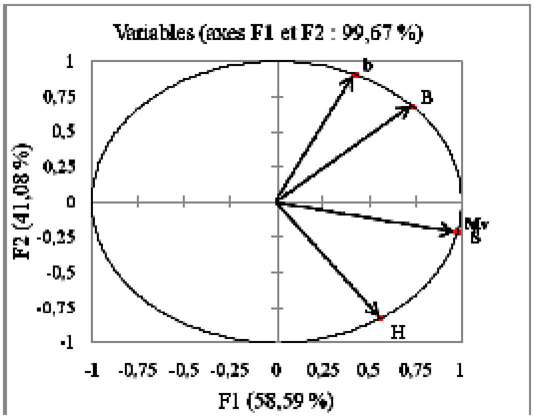

Fig. 2. Variables projection in the correlation circle

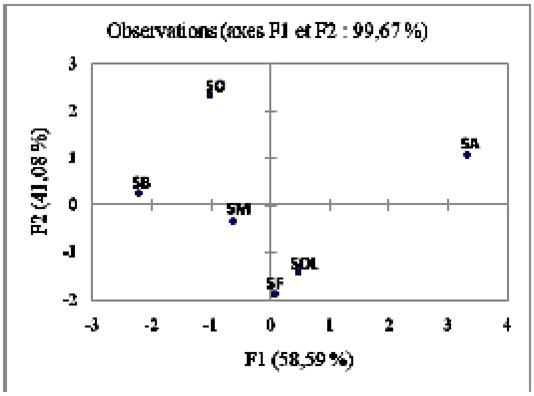

Fig. 3. Stations projection plane in the factorial 1-2 axes system

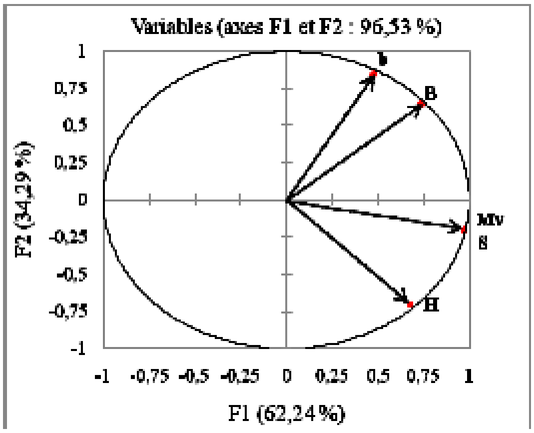

Fig. 4. Variables projection in the correlation circle

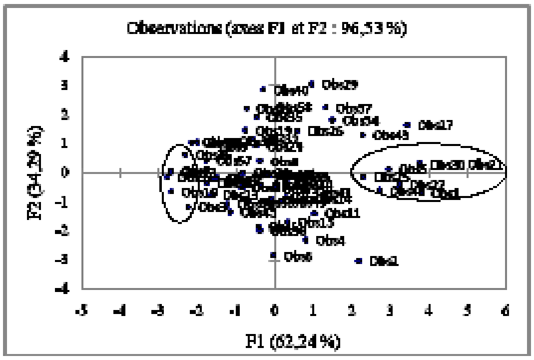

Fig. 5. Projection plane of observations in the factorial 1-2 axes system

The most distant points from the center are those which project the best in the factorial plane (Fig. 3). Note that the 1 axis between the two stations SA (Aïn Fezza) and SB (Boudjmil), is explained by the fact that SA station is the largest in the area from the point of view of compacted soil area (S_{SA} = 0.0784 m^2) and of the compacted soil density (Mv_{SA} = 141.12 Kg/linear meter (ml). According to the average of the surface and the density of the compacted soil, we can classify the stations in the following order: SAÃ SOLÃSFÃ SMÃSOÃSB.

This difference between the study stations probably amounts to the lack of balance in the actual load herds (Table 2), taking into account the slope change from a station to another. It thus appears that the more the slope is significant (25%) the more compaction is important.

Herd composition shows a predominance of sheep, they occupy about 73% of the total. These results corroborate those of Benabadji *et al*[21].These authors add that the investigation and field observations indicate a significant impact of grazing on soil. During the winter season, the passage of herds necessarily leads to a superficial soil compaction, the scale can vary according to the proportion of fines, in particular clays.

The gregarious behavior of these domestic animals (sheep, cattle and goats) increases the importance of levies on the herbaceous layer they use (overgrazing). This behavior increases the effects of trampling which devastate the vegetation. In addition to the intense grazing, the consecutive trampling due to the passage of an excessive number of animals bares the soil along the herds moving tracks. Similarly, Marion[24] reported that a high stress can limit the number of plant species while leading to a diversification of strategies to face this constraint.

The projected 60 observations are shown in Figure 5. We see that the first line F1 returns 62.24% of the inertia and the second axis F2 34.29%; with these two we than have 96.53% of the information, that is almost all.

Note that two groups (1 and 2) are the best represented in the axis 1. The group 1 (Obs: 1, 5, 21, 22, 30 and 48) on the right, this is the only group with the most important values in surface (m^2) and density (kg/ml) of compacted soil (tables 4, 6and8). The variables S and Mv have a strong contribution to the similarity of observations (1, 5, 21, 22, 30 and 48). We deduce that this group represents compacted soils by cattle trampling, resulting in a more abundant runoff and significant erosion. On the left, group 2 (Obs: 3, 7, 9, 10, 13, 52, 54 and 56) is better represented on the negative side of the axis 1, since it has the lowest values in S and Mv of the compacted soil (tables 4, 5 and 9) and these two variables also contribute greatly in the similarity of these observations.

Observation 2 is best represented in the axis 2. It presents the most important value in minor base (b = 2.13m) compared to the other two stations (Frawna and Oued Lakhdar).

The statistical processing shows that the action of some herds is obvious in the various stations. Once the vegetation cover degraded, biomass reduces and the litter disappears in passing herds, runoff on these tracks leads to erosion rill, compaction and stripping of the topsoil between the shrubs clumps and chamaephytes.

According to Gunnell[25], the stress to which plants are subjected by overgrazing is linked to consuming prior to grains; some Poaceae species deteriorate in favor of short-cycle species, causing a biological impoverishment and loss of biodiversity.

When land degradation is driven by overgrazing, there are only dwarf palms (*C.h*), cistus, thorny, broom and various non-palatable grasses. Sabir and Roose[26] consider that if scrublands are dense and closed for protection, they protect the soil against rainfall energy almost as well as the forest.

CONCLUSION

The repeated passage of herds exposes the soil to compaction phenomenon. This phenomenon has been studied by several measurements to determine the surface and the density of anthropized soils (compacted). The use of statistical tests (ANOVA 1, PCA) showed highly significant correlations between the surface and the density of the soil compacted (r = 1.000).

The more the surface of compacted soil increases, more the density of the compacted soil increases and only these two parameters have a significant contribution in the explanation of the phenomenon of compaction from one station to the other according to the correlation circle.

From this we have three groups:

1- Soil with high exposure to the phenomenon of compaction; it is the case in Aïn Fezza station.

2- Soil moderately exposed to the phenomenon of compaction; it is the case of Oued Lakhdar, Frawna, Mafrouch and Ouchba stations.

3- Soil with low exposure to the phenomenon of compaction and shown only by the Boudjmil station.

This difference is explained by the uneven loads of herds in the studied stations.

In this situation of soil compaction, water infiltration capacity is reduced which increases runoff during rainfalls. Unfortunately, the vegetation potential is constantly threatened by erosion which impact is even stronger than the soils are sloping and are not stabilized by vegetation, which, less supplied with water, becomes sparse then disappears; and then, flora is impoverished, the biomass production decreases.

A solution to this environmental degradation is a sustainable pastoralism based on a Chamaeropaie regulation course.

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