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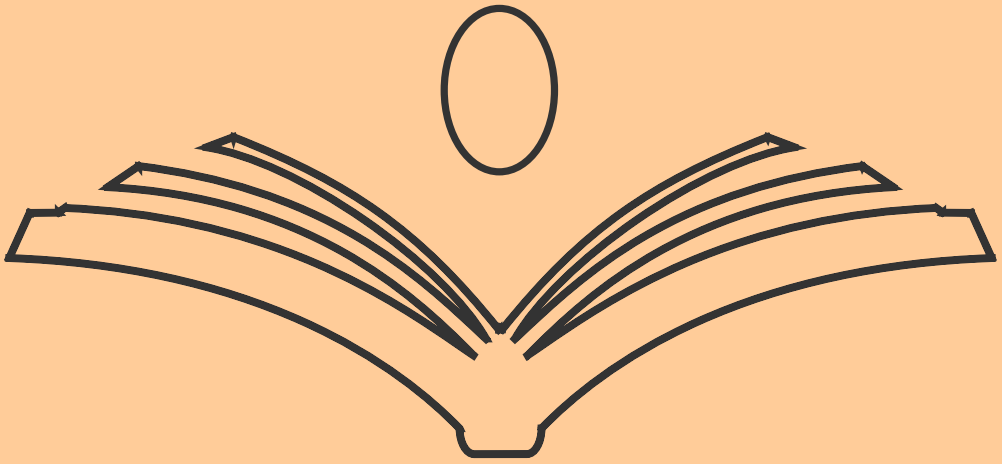

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Full Length Research Paper

The Heuristic Principle of Inability with an Application on the Set Theoretical Linear Continuum

Karim Daghbouche *
Hanover (Germany)

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ABSTRACT

This paper proposes a mathematical generalization of certain epistemological inabilities with heuristic implications for philosophy in general and mathematical set theory specifically. With "*The world is real. But not reality.*" constituting the ontological commitment and "*everything is number*" being the enforced working hypothesis throughout the here presented, a *heuristic principle of inability* is postulated and further abstracted in set theoretical terms with a variation of the *Cantor set*. The derived properties of this variation in conjunction with the application of the heuristic principle of inability yield new aspects of *reality* which eventually motivate an *axiom of reality* based on a *single abstractum per definitionem*.

Key words: epistemology, abstract set theory, linear continuum, cantor set, heuristic, real, reality, everything is number, one

INTRODUCTION

"The world is real. But not reality." shall serve as our ontological commitment for the here presented conjectures. It reflects epistemological limits with a heuristic approach on the non-increasable absolute adjective "real".

In order to orchestrate the heuristics, we associate any axiom with a limit. Whatever is not deducible out of it or whatever is in contradiction to it is deemed unreachable. Nevertheless, this principle can be inverted: If a formal system reaches limits in its specific field of application which cannot be overcome, independent of the degree of effort spent, it may pave the way for new solutions, to knowledge increase, and eventually to new axioms.

In a methodological sense, the heuristic principle of inability defines any problem by its solution, so that in many cases it may be that the original problem will be altered by the solution, i.e., that the original problem will be redefined by a new axiom.

Picturing the tremendous efforts by countless inventors, e.g., to design a mechanism, which was intended to work energetically self-sufficient, provides with a well-established illustration of the heuristic principle of inability [cf. Born 1962]:

Eventually, the failure to succeed with a *perpetuum mobile* was formalized and represents a fundamental physical law to-day, namely the *law of conservation of energy*. [cf. Whittaker 1949] [1]

Analogously, the *second law of thermodynamics* was derived from the inability to transform thermal energy

*Corresponding author: karim.daghbouche@gmail.com

[1] *Whittaker* called it "*postulates of impotence*"

without energetic effort, i.e., without work. Unlike the first law of thermodynamics, this second law of thermodynamics doesn't represent a conservation of a physical value, but rather states that a certain value called "*entropy*" is constant, i.e., *irreversible*.

With a logic criticism of the concept of *simultaneousness* as well as of the inability to observe the postulated *ether* as the carrier for electromagnetic phenomena, the well-established *Theory of relativity* provides another illustrative example of the heuristic principle of inability:

While it was state-of-the-art in the scientific community to try to materialize the *ether* through various empirical measures, all efforts to do so failed persistently [Michelson and Morley 1887]. Eventually, *Newtonian mechanics* were in course of modification by physicists like *Hendrik Antoon Lorentz* (1853-1928) and *Poincaré* (1854-1912) which proved successful to a certain extent.

In this contest it was *Einstein* (1879-1955) who declared the inability to materialize an *ether* as a principle by assuming the speed of light to be constant and independent of any state of motion [Einstein 1905]. Consequently, the physical concept of simultaneousness needed to be amended in order to avoid the *circulus vitiosus,* which originated by the fact, that an empirical establishment of the speed of light requires the value of the latter beforehand to synchronize the very clocks used for the measurement.

As a matter of fact, the original problem of the *ether* was replaced by a new view of physical dynamics.

Together with the impossibility to distinguish between *inertial* and *gravitational* mass properties of *Newtonian mechanics*, the *Equivalence principle* of *Einsteins's General relativity* and the new *relativistic dynamics* led to a deep revision and increased interdependency of the concepts of space, time, matter, energy, and electromagnetism.

In the same time, the emergence of *quantum mechanics* shed a different light on determinism than it was previously anticipated. It may serve as prime-example of our heuristic principle of inability:

Before the discovery of the *Uncertainty principle* [Heisenberg 1927], it was assumed that physical values such as *location coordinate* and *motion quantity* could at least theoretically be measured to whatever degree the spectrum of real numbers $\mathbb{R}$ would allow to, i.e., with infinite precision in terms of decimals. In contrast in turned out, that the location coordinate is always conjugated to the motion quantity in a sense that the precision of measurement remains always below an absolute limit, namely the *Planck constant* h yielding the aspect of *complementarity* which will be introduced in the final part of this paper.

But as in the previous historic examples, setting the conjugation with its absolute limit as principle not only limited the scope of the deterministic paradigm, but led physics to elaborate and control the mechanics of measurement sensitive objects as observed in atomic and subatomic scales, i.e., the field of application and the associate knowledge grew.

EPISTEMOLOGICAL PART

In order to establish a sound philosophical framework for the introduction of the heuristic principle of inability, it is indicated to sum-up the epistemological essence laid out in the historic examples:

Firstly, there is a fundamental inability for an axiom or set of axioms to cope with certain phenomena or paradigms.

Secondly, this inability is set as a principle, i.e., as a new axiom.

Thirdly, the new axiom redefines the problem where the inability first applied.

As a next step, we increase the level of abstraction for this epistemological process as a whole by only investigating the formal aspect of it, i.e., by analyzing how language is projected to the objects of our imagination and perception.
In Figure 1, *N* represents natural language and *A* axiomatized (or formalized) language (such as mathematics). The languages are symbolized in "boxes" to express their actual finiteness in terms of symbols and grammar. The axiomatized language *A* is symbolically a subset of *N* because it is thought to be less expressive than natural language, i.e., natural language generally acts as the meta-language of axiomatized languages.

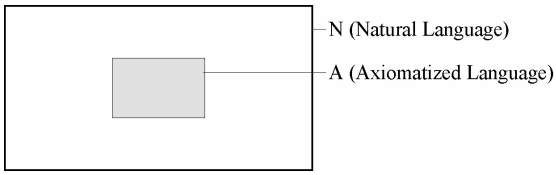

Figure 1

Being equipped with language, we project (*P*) it to objects of our imagination and perception, symbolized as reality (*R*) [Figure 2]:

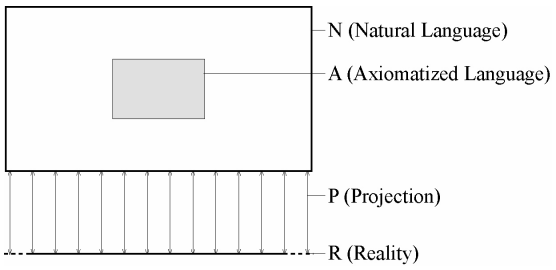

Figure 2

This projection is critical in multiple aspects with the circularity yielding an infinite regress being obvious: Any object of perception or imagination requires a corresponding term in language and *vice versa*, we only perceive or imagine reality in terms of our language capabilities (the projection (*P*) is reciprocal)[2].
According to our ontological commitment, the by far most critical aspect however seems to be represented by the fact of applying language to objects of our imagination and perception at all: *The act of projecting language to reality (and vice versa, reality to language) necessarily reduces reality to the circularity of our language and perceptive capabilities, whether axiomatized, instrument assisted, or not.*
Or, as *Azzouni* recently pointed out: "[…] what resources are available to argue for a criterion for what exists? Philosophers typically employ ontic intuitions, methodological claims, and (sometimes) descriptions of scientific practice in their philosophical arguments for one or another criterion. Establishing that argumentation for any such criterion always yields indeterminate fruit, therefore, might seem to require an analysis (or at least a survey) of more than two thousand years of metaphysical thought." [Azzouni 2010]

In order to further strengthen and explore the conjecture of the principle inability without discussing the various ontological and semantic concepts, we will investigate the most abstract and simple *objects* of our language, namely the mathematical linear continuum and

[2] An exception is constituted by *meditation* where any language and affects are kindly released. Consequently, this meditative aspect of perception cannot be communicated in any language.

its constituents (*points* or *numbers*) [Figure 3]:

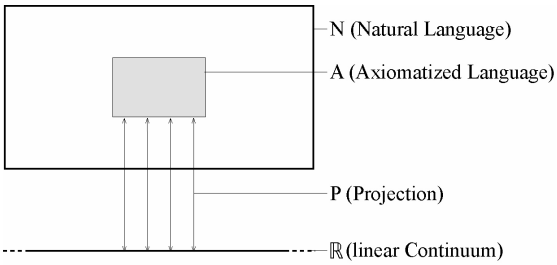

Figure 3

Applying the *Pythagorean* statement "*everything is number*", our working hypothesis essentially consists of substituting the term "reality" with the continuum while preserving our language tools (natural + axiomatized) and defining projections as *bijective* functions (one-to-one correspondences).

It shall enable us to focus on abstract processes of projections in sufficiently defined terms (if ever) as well as on a strict formal discussion where any object of our "reality" is projected to just numbers or points.

If we can provide formal evidence that the establishment of a single point and the associated linear continuum of points represents a fundamental inability, it is assumed to have a strong argument for having formalized our heuristic principle of inability in a most general sense. The heuristic aspect, i.e., a new set theoretical meta-axiom along with some empirical leads, shall constitute the concluding part of this paper.

FORMAL PART

Following the most influential analysis of the foundations of set theory to connect discrete points or numbers to a continuum, *Abraham Fraenkel* (1891-1965), *Yehoshua Bar-Hillel* (1915-1975) and *Azriel Levy* (1934-) concluded that "Bridging the gap between the domains of discreteness and continuity, or between arithmetic and geometry is a central, presumably even the central problem of the foundations of mathematics." [Fraenkel 1973].

This debate can be traced back as far as to the *Eleatic* philosophers such as *Parmenides* (515 B.C.), and *Zeno* (460 B.C.) [cf. Stokes 1971].

Putting a time-stamp on the reinitiation of the whole discussion, *Karl Weierstrass* (1815-1897) could be regarded as the father of modern analysis being the first to come up with a complete arithmetization of mathematical analysis. To do so, *Weierstrass* defined a positive real number to be a countable set of positive rational numbers for which the sum of any finite subset always remains below a pre-assigned bound. Eventually, he broke down conditions which would enable a comparison of two such “real numbers” in terms of equality or magnitude (strictly smaller than one another) [cf. Bell 2010].

But the most revolutionary thinker in contemporary history was *Georg Cantor* (1845-1918). His view of the continuum as infinite point sets laid the foundations of his theory of transfinite numbers. From there on, the geometric origin of the continuum as a collection of points was transferred to the current concept of general abstract set theory.

Just like *Weierstrass* and *Richard Dedekind* (1831-1916), *Cantor* intended to provide a definition of real numbers which avoids their a priori existence. To do so, *Cantor* looked at rational numbers and following *Cauchy* (1789-1857), he called a sequence of rational numbers a_1, a_2,…, a_n,… a *fundamental sequence* if there exists an integer N such that, for any positive rational ε, there exists an integer N, such that $|a_{n+m} - a_n| < \varepsilon$ for all m and all $n > N$. Any sequence $< a_n >$ which satisfies this condition is then said to have a *definite limit b*. *Dedekind* interpreted irrational numbers as "mental

objects" associated with cuts (*Dedekind cuts*). In analogy, *Cantor* regarded these well-defined limits as *symbols* which represent *fundamental sequences* (hereafter *Weiserstrass-Dedekind-Cantor program*). Accordingly, the domain *B* of limit points are considered an enlargement of the domain *A* of rational numbers, i.e., representing real numbers. *Cantor* showed that every single point of the line corresponds to a definite element of the domain *B* while each element of *B* determines a definite point on the line. Without providing proof of this intuitive property of the continuum, *Cantor* introduced it as an axiom, just as *Dedekind* had done with his own *principle of continuity*. We will get back to this constitutive axiom further down.

While prior *Cantor's* work the continuum has essentially been regarded as an unanalyzable concept, *Cantor* gave it an arithmetic framework. With this at hand, he identified the set of points thought as the linear continuum with numbers, enabling the comparison of "sizes" of point sets with the well established concept of *unambiguous bijections* [Figure 4 and 5]:

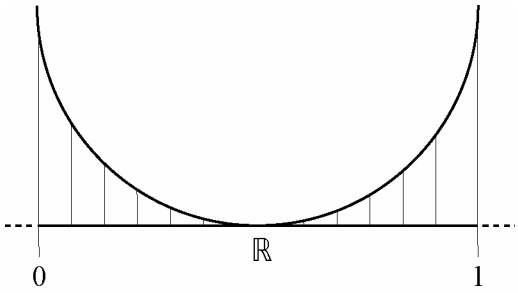

Figure 4 Every point of the finite unit interval [0;1] which is part of the infinite linear continuum ℝ, has a *bijective* projection to the points of the semi-circle (1:1 correspondence).

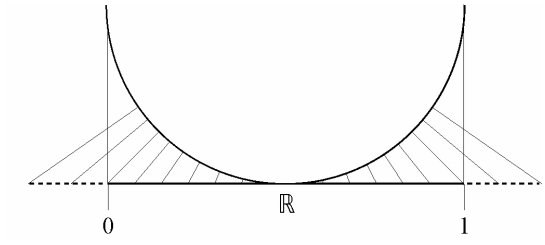

Figure 5 Analogously, every point of the infinite linear continuum ℝ has a *bijective* projection to the points of the semi-circle (1:1 correspondence), hence, the number of points of the finite unit interval [0;1] is the same as of the total linear continuum ℝ (again a 1:1 correspondence).

Cantor not only showed that a finite unit interval [0;1] of an infinite line has the same *cardinality* (*magnitude* or *power* in terms of *number of elements*) as the infinite line itself, but he also generalized this finding and showed, that all spaces E^n have the same cardinality as the set of real numbers in the one dimensional, finite unit interval [0;1]. Eventually, *Cantor* stated the hypothesis (*Continuum Hypotheses* or CH), that any infinite point set has either the cardinality of the set of natural numbers $\mathbb{N}$ which are denumerable, i.e., $\aleph_0$ (aleph zero), or that of the non-denumerable unit interval [0;1] of the real line, i.e., $2^{\aleph_0} = C$ which has the next highest cardinality $\aleph_1 = C$.

Referring to the definition of real numbers in terms of fundamental sequences, *Cantor* introduced the *Euclidean n-space* E^n as the set of all *n*-tuples of real numbers $<x_1,x_2,\ldots,x_n>$, calling each such an *arithmetical point* of E^n. The distance between two such points is represented by

$$\sqrt{\left(x_1' - x_1\right)^2 + \left(x_2' - x_2\right)^2 + \ldots + \left(x_n' - x_n\right)^2}$$

Eventually, an arithmetical point-set in E^n is any point-aggregate of the points of the *Euclidean n-space* E^n.

Having singled out E^n as the analytical framework of the linear continuum, *Cantor* defined the derived set of a point set *P* to be the set of *limit points* of *P*, where a limit point of *P* is a point of *P* with infinitely many points of *P* arbitrarily close to it [Cantor 1932: 140].

He called a point set *perfect* if it coincides with its derived set. *Cantor* himself realized that the condition of "perfectness" is insufficient to characterize the intended, intuitive continuum. He noticed in a footnote [cf. Cantor 1932: 207] that one could construct perfect sets which are just nowhere dense in any interval of the linear continuum. Today it is coined "*Cantor set*" or "*Cantor ternary set*" and constitutes an illustrative argument in furtherance of our heuristic principle of inability:
Following *Cantor*, a perfect, nowhere dense set in any closed interval of the linear continuum $\mathbb{R}$ is defined as real numbers such as:

Def. 1 $$x = \frac{c_1}{3} + \ldots + \frac{c_v}{3^v} + \ldots$$

where c_v can be regarded as having the values 0 or 2 for each integer v. [cf. Fleron 1994]

Def. 2 A set S is perfect if $S = S'$, where S' is the set of all the limit points of S.

Def. 3 A set S is nowhere dense if the interior of the closure of S is empty.

Cantor introduced this set as simply as:

Let I be an interval [0;1]. Split I into thirds. Remove the open set that represents the middle third and let A_1 be the remaining set:

Def. 4 $$A_1 = \left[0,\frac{1}{3}\right] \cup \left[\frac{2}{3},1\right]$$

Removing the open middle third interval from each of the two closed sets in A_1 continuously yields the remainder A_2:

Def. 5
$$A_2 = \left[0,\frac{1}{9}\right] \cup \left[\frac{2}{9},\frac{1}{3}\right] \cup \left[\frac{2}{3},\frac{7}{9}\right] \cup \left[\frac{8}{9},1\right]$$
Each consecutive step k for $k \in \mathbb{R}$ consists of removing the open middle third interval from each of the closed sets in A_k. We call the remaining set A_{k+1}. For each $k \in \mathbb{R}$, A_k is the union of 2^k closed intervals each of *length* 3^{-k}.

Def. 6 $$C_3 = \bigcap_{k=1}^{\infty} A_k$$

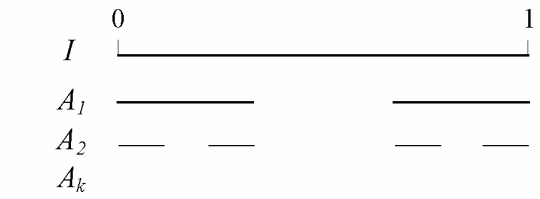

Figure 6 Consecutive removal process of the middle third interval of every closed interval leaving a single point *"extended" with maximum "disconnection" over the whole unit interval* [0;1] (cf. fn 3: 13).

The ternary (base 3) expansion of the *Cantor set C* only consists of 0s and 2s because at any step of removal, every number with a ternary expansion containing a 1 is removed. In the first step of the removal any number remaining can be viewed of having the digit $c_1 = 0$ or 2 where $x = 0.c_1c_2c_3\ldots$, because if $x \in \left[0,\frac{1}{3}\right]$, $c_1 = 0$ and if $x \in \left[\frac{2}{3},1\right]$, $c_1 = 2$.

For x remaining after n removals, the repetition for each step of removal yields c_n being either 0 or 2.

The constitutive properties of the *Cantor set* C_3 are severally proven [cf. Wikipedia 2012] so that we will just list them as follows and eventually get into one or the other proof, as required:

- non-denumerable (cardinality of the continuum)
- contains no intervals (all intervals were removed)
- zero lenght (*Euclidian point topology* in E^n)
- compact (countable many endpoints)
- nowhere dense (no connected points at all)
- *Hausdorff dimension* log2/log3

In order to hold on to his "intuitive" definition and not being obliged to consider constructions of perfect sets in the manner of C_3 as a continuum, *Cantor* introduced an additional condition which he called a "*connected set*" representing a metric definition: A point set T is connected in *Cantor's* sense if for any pair of its points t, t' and any arbitrarily small number ε there is a finite sequence of points t_1, t_2,…, t_n of T for which the distances $[tt_1]$, $[t_1t_2]$, $[t_2t_3]$, …, $[t_nt']$ are all less than ε. *Cantor* was now able to define a continuum to be a *perfect connected point set*: "Die *perfekten* Punktmengen S sind keineswegs immer in ihrem Innern das, was ich in meinen vorhin genannten Arbeiten "überalldicht" genannt habe[11)]; deshalb eignen sie sich auch noch nicht allein zur vollständigen Definition eines Punktkontinuums, wenn man auch sofort zugeben muß, dass letzteres stets eine *perfekte* Menge sein muß.
Es ist vielmehr noch ein Begriff erforderlich, um im Verein mit dem vorhergehenden das Kontinuum zu definieren, nämlich der Begriff einer *zusammenhängenden* Punktmenge T.
Wir nennen T eine *zusammenhängende* Punktmenge, wenn für je zwei Punkte t und t' derselben bei vorgegebener beliebig kleiner Zahl ε immer eine endliche Anzahl Punkte t_1, t_2,…, t_v von T auf mehrfache Art vorhanden sind, sodaß die Entfernungen tt_1, t_1t_2, t_2t_3, …, t_vt' sämtlich kleiner sind als ε. [Es handelt sich also um eine "metrische" Eigenschaft des Kontinuums.]
Alle uns bekannten geometrischen Punktkontinua fallen nun auch, wie leicht zu sehen, unter diesen Begriff der *zusammenhängenden* Punktmenge; ich glaube aber nun auch in diesen *beiden* Prädikaten "perfekt" und "zusammenhängend" die notwendigen und *hinreichenden* Merkmale eines Punktkontinuums zu erkennen und definiere daher ein Punktkontinuum innerhalb G_n als *perfekt-zusammenhängende Menge*[12)]. Hier sind "perfekt" und "zusammenhängend" nicht bloße Worte, sondern durch die vorangegangenen Definitionen aufs schärfste begrifflich charakterisiert, ganz allgemeine Prädikate des *Kontinuums*." [Cantor 1932: 194]

As introduced earlier, both, *Dedekind* and *Cantor*, were fully aware of the axiomatic, yet not necessary assumption of any continuity within the apparently perceived, three dimensional physical space, which both however considered as *reality*: "An diese Sätze knüpfen sich die Erwägungen über die Beschaffenheit des der realen Welt, zum Zwecke begrifflicher Beschreibung und Erklärung der in ihr vorkommenden Erscheinungen, zugrunde zu legenden dreidimensionalen Raumes. Bekanntlich wird derselbe sowohl wegen der in ihm auftretenden Formen, wie auch namentlich mit Rücksicht auf die darin vor sich gehenden Bewegungen als *durchgängig stetig* angenommen. Diese letztere Annahme besteht nach den gleichzeitigen, voneinander unabhängigen Untersuchungen Dedekinds (M.s. das Schriftchen: Stetigkeit und irrationale Zahlen von R. Dedekind, Braunschweig 1872) und des Verfassers (Mathem. Annalen Bd. V, S.127 und 128) [II5, S.96] in nichts

anderem, als daß jeder Punkt, dessen Koordinaten *x, y, z* in bezug auf ein rechtwinkliges Koordinatensystem durch *irgendwelche* bestimmte reelle, rationale oder irrationale Zahlen vorgegeben sind, *als wirklich zum Raume gehörig* betrachten wird, wozu im allgemeinen kein innerer Zwang vorliegt und worin daher ein freier Akt unserer gedanklichen Konstruktionstätigkeit gesehen werden muß. Die *Hypothese der Stetigkeit des Raumes* ist also nichts anderes, als die an sich willkürliche Vorraussetzung der vollständigen, gegenseitig-eindeutigen Korrespondenz zwischen dem dreidimensionalen *rein arithmetischen Kontinuum* (*x, y, z*) und dem der Erscheinungswelt zugrunde gelegten Raume.[1]
Unser Denken kann aber mit gleicher Leichtigkeit von einzelnen Raumpunkten, sogar wenn sie überalldicht vorkommen, sehr wohl abstrahieren und sich den Begriff eines *unstetigen* dreidimensionalen Raumes von der im vorhergehenden charakterisierten Beschaffenheit bilden. Die sich alsdann ergebene Frage, ob auch in so *unstetigen* Räumen *stetige Bewegung* gedacht werden könne, muß nach dem Vorangehenden unbedingt *bejaht* werden, weil wir gezeigt haben, daß je zwei Punkte eines Gebildes durch unzählig viele stetige, vollkommen reguläre Linien verbunden werden können. Es stellt sich also merkwürdigerweise heraus, daß aus der bloßen Tatsache der stetigen Bewegung auf die durchgängige Stetigkeit des zur Erklärung der Bewegungserscheinungen gebrauchten dreidimensionalen Raumbegriffs zunächst kein Schluß gemacht werden kann. Daher liegt es nahe, den Versuch einer modifizierten, für Räume von der Beschaffenheit gültigen Mechanik zu unternehmen, um aus den Konsequenzen einer derartigen Untersuchung und aus ihrem Vergleich mit Tatsachen möglicherweise wirkliche Stützpunkte für die Hypothese der durchgängigen Stetigkeit des der Erfahrung unterzulegenden Raumbegriffs zu gewinnen." [Cantor 1932: 156-157]

To bridge the different concepts of arithmetic and geometry, *Cantor* finally needed to introduce the axiom of connecting any arithmetic value to a specific point of a line: "Daß nun ebenso auch die Zahlengrößen der Gebiete *C, D,* … befähigt sind, bekannte Entfernungen zu bestimmen, ergibt sich ohne Schwierigkeit. Um aber den in diesem § dargelegten Zusammenhang der Gebiete der in §1 definierten Zahlengröße mit der Geometrie der geraden Linie vollständig zu machen, ist nur noch ein *Axiom* hinzuzufügen, welches einfach darin besteht, daß auch umgekehrt zu jeder Zahlengröße ein bestimmter Punkt der Geraden gehört, dessen Koordinate gleich jener Zahlengröße, und zwar im dem Sinne gleich ist, wie solches in diesem § erklärt wird[1].
Ich nenne diesen Satz ein *Axiom*, weil es in seiner Natur liegt, nicht allgemein beweisbar zu sein.
Durch ihn wird denn auch nachträglich für die Zahlengrößen eine gewisse Gegenständlichkeit gewonnen, von welcher sie jedoch ganz unabhängig ist." [Cantor 1932: 97]

Having singled out the intuitive path of the *Weiserstrass-Dedekind-Cantor program* explicitly in terms of *connectivity*, *continuity*, and *arithmetization*, it is about time to account for the implicit consequences. As multiply shown, their axiomatic program intended a *complete arithmetization* along with a *geometric materialization* of the continuum.
The great idea was to combine arithmetic notions and associated values as *the*

discrete per definitionem with metric continuity.
In arithmetic, we consider those values as different which differ in any term *a*, no matter in which position $(a_1a_2a_3...a_n)$. Or else, without any exception, all arithmetic values have to be considered as equivalent with the concept of distinct numbers being obsolete. Accordingly, the distinct character of arithmetic values represents *Cantor's* key argument for the non-demunerability of the set of real numbers $\mathbb{R}$ [cf. Cantor 1991: 35; letter to *Dedekind* 7.12.1873].

In geometry, a point shares the same distinct property as long as observed isolated. Therefore, the *bijective* connection between arithmetic values and geometric points seems evident.
However, applying the *axiom of continuity* may yield to the asymmetry of a discrete but connected continuum which may neither be a necessary nor a commonly "desired" property of the latter.
Therefore, thinkers such as *Brentano (*1838-1917), *C. S. Peirce* (1839-1914)*, Poincaré*, *L. E. J. Brouwer* (1881-1966) and *Weyl* (1885-1955) to name a few, were opposed to the concept of a discrete but connected continuum. For any aggregate number of geometric points maintains zero topological dimension just as any aggregate of numbers will remain different if they differ in any decimal. If points however would constitute a dimensional object such as a continuous line, it would imply that the continuity of every point would be constituted by smaller points, and that: *ad infinitum*. But as soon as we try to constitute a geometric line with formerly isolated points connected to arithmetic values, the chasm between the discrete and continuity unfolds as deep as this ancient debate already lasts.

The crucial point to define the continuum throughout the whole debate, from the ancients to the here presented, consists of having *recognized* the constraints imposed by holding to any idea of space metric and associated topology, but having *failed to interpret* this constraint *formally*.
In an effort to deliver an appropriate formalization, we will now enforce the idea of a total arithmetization of the linear continuum. Therefore, we generalize C_3 in a way, that any topological dimension whatsoever is eliminated:
While it can easily been shown that although C_3 is has the *Lebesgue measure* of a single point of *Euclidian* dimension zero due to the removal of all one-dimensional line intervals with total length 1 [cf. Wikipedia 2012], C_3 can still be associated with a so called *Hausdorff dimension* [cf. Hausdorff 1919] in a *non-Euclidean Hausdorff topology* with

$$\dim(C_3) = \frac{\log 2}{\log 3} \approx 0.63$$

A variation of deriving the *Cantor set* will provide us with *Hausdorff* $\dim(C_k) = 0$ so that we look at a non-dimensional *point* without any topologic association whatsoever as follows [cf. Falconer 1985]:

Def. 7 The dimension of the *Cantor ternary set* (C_k) is: $d = \dfrac{\log \frac{1}{2}}{\log\left(\frac{1}{2} - \frac{1}{2k}\right)}$

Def. 8 Let $\{\Phi_i\}_{i=1}^{k}$ be a collection of similarities such that $E \subseteq \mathbb{R}^n$ is invariant with respect to $\{\Phi_i\}_{i=1}^{k}$. If $\{\Phi_i\}_{i=1}^{k}$ satisfies the open set condition and r_i will be the ratio of the *i*-th similarity Φ_i, then the

Hausdorff dimension of E is equal to the unique positive numbers for which $\sum_{i=1}^{k}(r_i)^s = 1.$

Let $\{D_k\}$ now be a collection of sets defined by k for $k \geq 2$ (for k=0 or k=1 either no interval at all or the whole interval [0;1] will be removed not yielding the properties of a *Cantor set*) in which each set is build by a repetitive removal of an open interval of length $\left(1-\frac{2}{k}\right)$ from the center of each closed interval [0;1]. Only intervals of length $\frac{1}{k}$ will remain on each side. We now only vary the length of the *side intervals* in terms of k but keep the ternary property. Then we remove the interval in-between where the original method thought by *Cantor*, as already discussed, only removed the open middle third interval with no variation in terms of k, i.e., k was a constant with k=3.

Applying *Def. 7* we calculate the general *Hausdorff dimension* for any $k \geq 2$:

Let $\Phi_1(x)$ and $\Phi_2(x)$ be:

$$\Phi_1(x) = \left(\frac{1}{k}\right)x \quad \text{and} \quad \Phi_2(x) = \left(\frac{1}{k}\right)x + 1 - \frac{1}{k}. \qquad (1.0)$$

With $C_k = \bigcup_{i=1}^{2}\Phi_i(C_k)$ and $r_1 = \frac{1}{k}$ as well as similarly $r_2 = \frac{1}{k}$ we resolve s such that

$$\sum_{i=1}^{2}(r_i)^s = 1 \qquad (1.1)$$

and

$$2\left(\frac{1}{k}\right)^s = 1 \text{ iff } s = \frac{\log 2}{\log k} \qquad (1.2)$$

and finally:

$$\dim(C_k) = \frac{\log 2}{\log k} \qquad (1.3)$$

where

$$\lim_{k\to\infty}\dim(C_k) = \lim_{k\to\infty}\left(\frac{\log 2}{\log k}\right) = 0 \qquad (1.4)$$

As intended, we have a set C_k with *Cantor set* properties with

$$\dim(C_k) = 0, \quad (1.5)$$

i.e., that of a point of a *n-space* E^n without any topology just by dividing the interval [0;1] into three subintervals where the smaller the length of the side intervals $\frac{1}{k}$, *viz.*, the larger the removed length of the interval $\left(1-\frac{2}{k}\right)$, the more the *Hausdorff dimension* tends to 0.

Proposition 1 Any point of an arbitrary *n-space* E^n has the cardinality of the linear continuum $\mathbb{R}$.
Having provided C_k as a *point* of the *n-space* E^n without any topology but with *Cantor set* properties, it can been shown that the cardinality of a *single point* is equal to that of the linear continuum $\mathbb{R}$:

Proof For each step of the repetitive removal process of an open interval of length $\left(1-\frac{2}{k}\right)$ from the center of each closed interval [0;1] we can again combine a binary with a ternary notation as follows:
Since every closed interval only has one open one removed, we can look at C_k of having a ternary expansion. We define a

function $f(x)$ onto the unit interval [0;1] and write in base 3 for every $x \in C_k$ either "0" or "2" without using the digit "1". Consequently, $f(x)$ is the point in the closed interval [0;1] whose binary expansion is obtained by substituting each digit "2" in the ternary expansion of x by the digit "1". Eventually, all points of the unit interval [0;1] can be derived by this process while we already know about the unit interval [0;1] having the cardinality of the linear continuum $\mathbb{R}$. We know further, that any arbitrary *n-space* E^n has the cardinality of $\mathbb{R}$. Hence, the cardinality of a *point* is equal to that of the linear continuum $\mathbb{R}$.

Apparently, our concept of a single point requires some further analysis. If we hold to the axiom of connecting any arithmetic value to a specific point of a line, we would have to assign the value 1 to our *single point* C_k.[3]

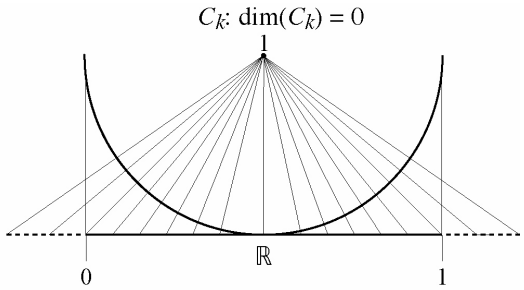

Figure 7 Every point of the infinite linear continuum $\mathbb{R}$ has a *bijective* projection to the points of C_k. While C_k is represented by a *single point* of the arbitrary *n-space* E^n without any topology defined thereon denoted with "1", it has the same cardinality as the whole linear continuum $\mathbb{R}$.

If this conjecture was not obvious with C_3 which still implied a topological dimension $\dim(C_3) = \frac{\log 2}{\log 3} \approx 0.63$, it became inevitably with C_k.

Stepping back to the very conception of the *Cantor set*, the supposed *paradox* of finding an equivalence between the cardinality of the linear continuum and a single point may result from missing clarity in the underlying assumptions of the very construction of the *Cantor set* with regard to *which* axioms are applied:

From a mere arithmetic perspective the apparent paradox is less obvious since we know that arithmetic values *per se* do not "occupy" any space which we consider as *physically* real. It is only the axiom of connecting arithmetic values to geometric points which may give rise to an apparent paradox, for a geometric line induces much more association to any space which we consider as physically real than just arithmetic values which may only occupy a designated, *imaginary arithmetic space* at the most.

But even this axiom is not yielding any paradox because as long as we do not associate a convention about a *physical distance* between any two distinct points (*A, B*) or arithmetic values (*x, y*), i.e., a *length* to any aggregate of points of a geometrical line, we can indeed "occupy" *any imaginable* number of points or arithmetic values in a non-spatial entity such as in a single point.

Cantor's concern was about defining a continuum to be continuous. He *only* defined an *Euclidean* standard metric in *arithmetic terms* onto the closed unit interval [0;1] where the "interval removal process" *only* demonstrates the whole interval being left as a point but with the same number of points as the initial unit interval [0;1] with the induced topology of the *Cantor set* being maximally disconnected, i.e., discrete vs. continuous.

However, this demonstration neither serves the purpose of holding to an idea

[3] Note in course of correction: further detailed consideration suggests E^n and the single integer point to be omni-equivalent.

of an *extended* nor of a *continuous* reality because with any appropriate number of points or numbers (hereafter referred to as *elements*), we can just define any metric we want onto the elements, discrete or connected, and that is *independent of any physical reality*, extended or not.

Therefore, the next important axiom enabling to hold to such an *extended*, *continuous* aspect of reality is the correspondence between a *physical entity* which is a *convention* about a *physical length* and between a *metric distance* of two elements.

Unless we admit physical space with zero spatial extension to our imagination which we will enforce in furtherance of this paper, a *Cantor set cannot be constructed physically* where the smallest theoretical length with physical yet not directly observable property would be the *Planck length* ℓ_p [cf. Wikipedia 2012; 2]. It is defined by three fundamental physical constants, namely by the speed of light in vacuum *C*, the reduced *Planck constant* $\hbar$, and the gravitational constant *G* as:

$$\ell_p = \sqrt{\frac{\hbar G}{c^3}} \approx 1.616199 \times 10^{-35}\,\mathrm{m}$$

where ℓ_p is a direct consequence of quantum mechanical measurement process which is restricted by *Heisenberg's uncertainty principle* as introduced earlier. Although the *Planck length* is a physical unit defining a discrete space metric, it is only about 10^{-20} of the diameter of a "proton" and thereby orders of magnitudes smaller than today's precision of measurement.

It is in this sense, that C_3 and C_k so far only prove that the space which we consider as physically real requires a convention about a metric system such as the *International System of Units* where among others, a length is a reference to e.g., light. Eventually, a *length unit* can be arbitrarily defined as the length of the path travelled by light in vacuum in a fixed, finite time interval [cf. Wikipedia 2012; 3].

Nevertheless, the most important axiom to explicitly observe when considering elements of our imagination or conventions about what we consider as physically real, is to connect the latter to *reality*.

Hence, equivalent to *proposition 1* would be the statement of a constant function *f* defined over all real numbers $\mathbb{R}$ having the value 1, i.e., $f(x) = 1 \quad \forall x \in \mathbb{R}$, where the projection of $\mathbb{R}$ is *surjective* onto 1 and with a single point being equivalent to C_k in terms of number of elements being *surjective* onto $\mathbb{R}$, i.e., having a *bijective* identity function $f(x) = x \quad \forall x \in \mathbb{R}$. But the identity can only hold if 1 is redefined in set theoretical terms being as well as both, a single unit *and* a multitude. It is therefore suggested, to shift the debate from the characteristics axiomatically and "intuitively" defined into the idea of an extended linear continuum to a closer look on the properties of 1.

To do so, we reconsider the *compact, perfect metric* of C_k and its *totally disconnected, discrete topology* which was inherited from the *Euclidean* standard metric *arbitrarily defined onto* the closed unit interval [0;1]. And just as having arbitrarily defined the *Euclidean* standard metric onto the closed unit interval [0;1], we arbitrarily *abstract* any metric property away from C_k as we previously did with its *Hausdorff topology* with just non-denumerable elements remaining as a *single point*.

Now we can consider the following proposition:

Lemma 1 1 has at least the cardinality κ of C_k with $|C_k| \leq |1|$.

Proof Since we know that 1 has at least the cardinality κ of C_k, we only need to show that the power set of C_k is at least equal to 1, i.e., $\mathcal{P}(C_k) \leq 1$.

To do so, we apply *Cantor's theorem*:
For any set A, the set of all subsets of $\mathcal{P}(A)$ has a strictly greater cardinality than A itself with $|\mathcal{P}(A)| > |A|$.

While the number of points of $\mathcal{P}(C_k)$ are strictly greater than C_k, $\mathcal{P}(C_k)$ has any metric and topology abstracted away, hence still remaining the single point 1.

Proposition 2 1 is at least equal to any cardinality κ_x with $\boldsymbol{\kappa}_x \leq |1|$.

Proof Since we know that 1 has at least the cardinality κ of C_k, we only need to show that there is always a subset A of C_k that is smaller than C_k, i.e., $A \subseteq P(A)$.

To do so, we apply the inversion of *Cantor's theorem*:
For any power set $\mathcal{P}(A)$, the set A is strictly smaller than $\mathcal{P}(A)$ with $|A| < |\mathcal{P}(A)|$.
Obviously, with a recursion on $|\mathcal{P}(A)| = |2^A|$ we can generate greater and greater power sets of any given set while the number of points of the ever-increasing power sets are always less or equal to the single point.

We reconnect this finding to *Cantor's* original view of magnitudes when he defined a cardinal number being the result of a *double abstraction* in the following sense:

Right after defining a set as *a gathering into a whole of definite, distinct objects of our perception and of our thought*, which *Cantor* called *elements of a set*, he describes cardinality as an abstraction from the nature of the elements *m* of a set *M*. With some order may being left within and among these elements *m*, one abstracts even from that order to compare the magnitude of any two sets *M* and *N* where the elements itselves cannot be distinguished any further all becoming "one" as an intellectual image or projection of any given set *M* existing in our spirit. For any set *N* that is *bijective* with *M* the cardinal number would eventually be the same, i.e., 1:
"*‚Mächtigkeit' oder ‚Kardinalzahl' von M nennen wir den Allgemeinbegriff, welcher mit Hilfe unseres aktiven Denkvermögens dadurch aus der Menge M hervorgeht, daß von der Beschaffenheit ihrer verschiedenen Elemente m und von der Ordnung ihres Gegebenseins abstrahiert wird.*
Das Resultat dieses zweifachen Abstraktionsakts, die Kardinalzahl oder Mächtigkeit von *M*, bezeichnen wir mit

$$\overline{\overline{M}}. \qquad (3)$$

Da aus jedem einzelnen Elemente *m*, wenn man von seiner Beschaffenheit absieht, eine ‚Eins' wird, so ist die Kardinalzahl *M* selbst eine aus lauter Einsen zusammengesetzte Menge, die als intellektuelles Abbild oder Projektion der gegebenen Menge *M* in unserem Geiste Existenz hat." [Cantor 1932: 282-283]

With that, the collection of all sets *N* with $|N| = |M|$ exists *ad infinitum* where for every *x,* the set $\{x\}$ has exactly one element $\{1\}$ with cardinality 1 so that the double abstraction leaves an object without any specific properties other than *existing*.
If now, according to *Cantor*, a well determined, *finished* set would have a

cardinality which would not correspond to any aleph, it would need to include subsets whose cardinality is *any* of the alephs, i.e., this set would need to carry the totality of alephs within itself: ",Wenn eine bestimmte wohldefinierte *fertige* Menge eine Cardinalzahl haben würde, die mit keinem der Alefs zusammenfiele, so müßte sie Theilmengen enthalten, deren Cardinalzahl *irgend* ein Alef ist, oder mit anderen Worten, die Menge müßte die Totalität aller Alefs in sich tragen.'" [Cantor 1991: 388; letter to *Hilbert* 26.9.1897]

In furtherance of this idea, we find 1 being *finite* with its ordinal number α and cardinal number κ being identical, i.e., 1. Hence, 1 is not any transfinite cardinal $\aleph$. However, *proposition 2* showed that $|1| \geq$ any κ which implies that 1 is *constant* and *at least equal* to the cardinal number $\aleph_0$ of $\mathbb{N}$, while being *always greater* than any $\aleph$:

Def. 9

$$\Omega = \{\alpha | \alpha \text{ is an ordinal number}\}$$

where for all ordinal numbers α there is an ordinal number β such that

$$|W(\alpha)| < |W(\beta)|.$$

Reinstating *Cantor's* question if there is a system ת (taw)
[of all alephs $\aleph_0, \aleph_1, \ldots, \aleph_\omega, \aleph_{\omega+1}, \ldots$]
of *all transfinite cardinal numbers* that is not an aleph [cf. Cantor 1991: 410; letter to *Dedekind* 3.8.1899] yields:

Proposition 3 $\{\aleph_\alpha | \alpha \in \Omega\} < 1 = ת$

Proof ת shall be a set with $\aleph^*$ being the *supremum* of a set of cardinal numbers $\aleph$ with $\aleph^* = \sup(ת)$.
Since the *supremum* of a set of cardinal numbers is itself a cardinal number, we have $\aleph^* \in ת$.
While ת contains all $\aleph^*$ with $\kappa \in ת$, hence ת not containing a greatest element and $\kappa = \aleph_\alpha$ so that $\kappa < \aleph_{\alpha+1}$, ת remains constantly 1 with $\kappa < \aleph_{\alpha+1} < |1|$.

With ת = 1 we apparently have a finished set (just as any aleph is considered to be a finished set) that has a cardinality which does not correspond to any aleph and which includes subsets whose cardinality is indeed *any* of the alephs, i.e., ת carries the totality of alephs within itself. However, the all-imposing question to be answered is whether ת is a *consistent set*.
Again with *Cantor* we find that if we consider any *finite* multitude to be consistent, we can extend this attribute to any *transfinite* multitude as represented by the alephs. And just as the consistency of any finite multitude solely depends on the unprovable axiom of arithmetic with 1+1 being 2, so is the extension to the transfinite arithmetic with its cardinal numbers represented by alephs:
"Man muß die Frage aufwerfen, woher ich denn wisse, daß die wohlgeordneten Vielheiten oder Folgen, denen ich die Cardinalzahlen $\aleph_0, \aleph_1, \ldots, \aleph_{\omega_0}, \ldots, \aleph_{\omega_1}, \ldots$ zuschreibe, auch wirklich ‚Mengen' in dem erklärten Sinne des Wortes, d.h. ‚konsistente Vielheiten' seien. Wäre es nicht denkbar, daß schon *diese* Vielheiten ‚inkonsistent' seien, und daß der Widerspruch der Annahme eines ‚Zusammenseins aller ihrer Elemente' sich *nur noch nicht bemerkbar gemacht hätte*? Meine Antwort hierauf ist, daß diese Frage auf *endliche Vielheiten ebenfalls auszudehnen* ist und daß eine genaue Erwägung zu dem Resultate

führt: sogar für endliche Vielheiten ist ein ‚Beweis' für ihre ‚Consistenz' nicht zu führen. Mit anderen Worten: Die Thatsache der ‚Consistenz' endlicher Vielheiten ist eine einfache unbeweisbare Wahrheit, es ist ‚*Das Axiom* der Arithmetik (im alten Sinne des Wortes)'. Und ebenso ist die ‚Consistenz' der Vielheiten, denen ich die Alephs als Cardinalzahlen zuspreche, ‚das Axiom der erweiterten, der transfiniten Arithmetik.' ..." [Cantor 1991: 412; letter to *Dedekind* 28.8.1899].

Accordingly, we have to consider ת = 1 to be a consistent multitude while at the same time, 1 is evidently finite and represents *absolute unity* being *the most common denominator*, literally in terms of arithmetic and figuratively in terms of a geometric point. There seems to be no other conclusion than considering 1 itself representing an *inconsistency at the very foundation of mathematics*.

CONCLUSION

It is evident, that continued abstraction eventually yields to some concept of unity which is necessarily *complementary*, i.e., incorporates properties that may appear to be contradictory: While *Cantor* shed light on entities thought to be transfinite, unifying the concepts of finiteness with the infinite, e.g., with the finite unit interval [0;1] on the linear continuum having the same number of elements as the whole infinite linear continuum itself, the next level of abstraction merges both concepts to the most abstract notion, i.e., to the unit of a point and 1:

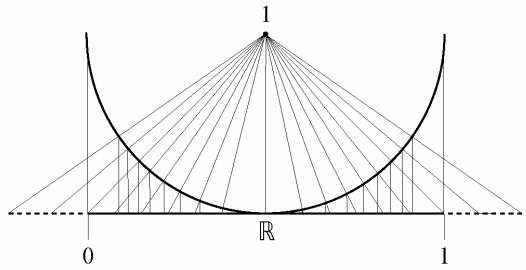

Figure 8 Continued *abstraction* unified the concepts of finiteness with transfiniteness and eventually with unity where the non-denumerable number of elements of the closed unit interval [0;1] of the non-denumerable number of elements of the real line ℝ are identical whereas 1 as single unit incorporates all of these non-denumerable elements and all possible power sets thereof including all subset of ℝ.

And no matter if we opt for the arithmetical language saying that "*everything is number*" or if we follow the geometrical track with *points* to express the projections of our imagination, at a certain stage of abstraction we have to account for the undefined or indefinable constituents of our *reality*. Otherwise our intuition about reality may be misled by the circularity imposed by unreflected language as introduced earlier in this paper.

To finally formalize our heuristic principle of inability, we implement our epistemological scheme and consider 1, a point, or the very notion "*something exists*" as the *most fundamental inability* of our language in terms of an inability of determination.

It is not surprising, that *Cantor* himself was very well versed in this essential constraint of language when he observed as well as agreed with *Spinoza* (1632-1677), that "*omnis determinatio est negatio"* [Cantor 1932: 175].

Next, we set the inability of determination as a principle where we define the *abstractum per definitionem* by inversion: "*omnis negatio est determinatio*", which is equivalent to the complementary expression that *total negation yields something* or *negation of*

totality yields something where "something" can still be "everything" *and* "a single thing".
The complementary nature of this "something" is different from what our common intuition and formal language previously suggested. We therefore substitute the *Latin* type-font for 1 with the corresponding *Arabic* font ١ leaving semantic freedom for both, *multitudes* and *diversity* as well as for *unity*, i.e., having distinguished it from a supposedly non-complementary, naïve arithmetic meaning.
A streamlined formal expression for a total negation suggests to look for an already commonly known yet *undefined expression* such as $0 \cdot \infty$ which we define as follows:

Def. 10 0 = negator
∞ = totality
١ = something

Axiom of reality $0 \cdot \infty = ١$

Finally, we apply the new axiom and redefine the debate about the linear continuum with the world of phenomena underlying reality where the inability of defining *reality* first appeared:
With ١ not only being the most inclusive and powerful notion containing all and any elements of our thought, imagination and perception, but at the same time also being the most fundamental entity, the question of an extended, connected, divisible or non-divisible multitude or just an indivisible single entity is redefined by the question about how any kind of reality could consistently be expressed.
In line with *Cantor*, our conclusion is that it cannot. The absolute, i.e., the absolute greatest (*sive Deus*) cannot be determined by us but only by itself: "Es versteht sich von selbst, dass hierunter [*transfinite numbers*] das Absolute d.h. das absolut Größte (sive Deus) nicht zu verstehen ist, welches nur durch sich selbst, nicht aber von uns determiniert werden kann; ..." [Cantor 1991: 174; letter to *Laßwitz* 3.2.1884]

The here presented *axiom of reality* is a complementary notion where multiple, apparently contradictory properties on highest level of abstraction, i.e., the most undefined expression, yields something (١).
Figure 9 tries to illustrate this process: leaving any determination outside of language, the most undetermined (١) unfolds in language as the most basic, abstract projection (1) for any kind of multitude, e.g., for a linear continuum.
However, since language is only a projection of a complementary notion, *1 is only real, but not reality*, i.e., it provides the foundation for multiple aspects of reality such as frequently encountered in consistent, abstract language:

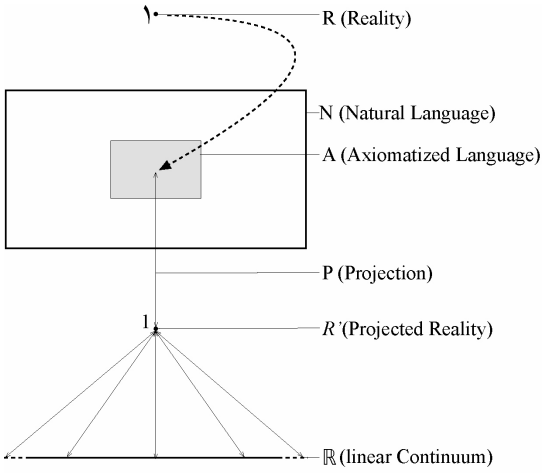

Figure 9 From a strict analytical perspective, it seems evident to first define the constituents of our abstract thought before extending them to multitudes, whether being points or numbers. On the other hand, we have to account for the process of language development which evidently works from naïve phenomenology to more and more differentiation only eventually leading to abstraction and unification.

If now the *axiom of reality* with its *total negation* or the equivalent *negation of totality* holds, it must not only provide our imagination with an intuitive idea about *what exists* and *how it exists* but it must also provide a prospective tool to deal with space as an *aspect of reality*.
It is in this sense, that our analytic tools, e.g., axiomatized language in association with natural meta-language, are only expected to be consistent whereas our hypothesis about what is *real* can at the most be subject to observables in order to be tried and tested (falsification).
Therefore, we can only presuppose *reality* according to our language capabilities while we associate the attribute "*real"* depending on our experience and its associated level of conformity, i.e., through empirical interaction in dedicated areas of application.
If however, a notion about *reality* would only be set equal to any kind of consensus with regard to which language to apply, e.g., *Euclidian Geometry* vs. *non-Euclidean Geometry* for our imagination about "space", or a consensus with respect to which conventions about physical units to apply, this would imply that *reality itself* would be subject to change concerning as well as both, *different languages* and a *consensus* about it whereas beforehand, the term "*reality*" is *per definitionem* independent of our subjective perception or imagination, i.e., "*reality*" is defined as being something *objective* vs. *subjective*, no matter what individually or collectively is considered to be *real*.
Two immediate physical aspects of this *reality* concern *quantum mechanical* phenomena. One is known as q*uantum entanglement* where *instant communication* between a *separated pair of photons* leads to the assumption of *entanglement*, also coined "*non-locality*" or "*non-spatial*" aspect of reality which requires a *deep revision* of our common intuition of *space topology* in a sense of *zero extension*. The other concerns an appropriate interpretation of a *relativistic quantum mechanical* expression known as "*Dirac equation"* $E = \pm\sqrt{p^2c^2 + m_0^2c^4}$ where what is called "matter" is unstable on principle with an implicit, infinitely-probable, total radiation-catastrophe (matter-antimatter annihilation) if considered as a single particle equation. Up-until today, only *asymmetric ad hoc hypothesis* in the *2nd quantization* of the *Dirac-field* with infinitely many additional particles assumed yield the self-evident conclusion that *the world exists*.

An ongoing effort will dedicate further publications to these physical aspects of reality as well as to set theoretical subjects.

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REFERENCES

Jody Azzouni [2010]: *Ontology and the word 'exist': Uneasy relations*. Philosophia Mathematica 2010, (**III**) 18:1: 75

John L. Bell [2010]: *Continuity and Infinitesimals*. The Stanford Encyclopedia of Philosophy (Fall 2010 Edition), Edward N. Zalta (ed.), http://plato.stanford.edu/archives/fall2010/entries/continuity

Max Born [1962]: *Die Grenzen des Weltbildes der Physik*. Leipzig: Akademische Verlags Gesellschaft 1962

Georg Cantor [1932]: *Gesammelte Abhandlungen mathematischen und philosophischen Inhalts*. Ed. Ernst Zermelo. Berlin: Springer 1932

Georg Cantor [1991]: *Briefe*. Eds. Herbert Meschkowski, Winfried Nilson. Berlin: Springer 1991

Albert Einstein [1905]: *Zur Elektrodynamik bewegter Körper*. Annalen der Physik und Chemie. **17** 1905: 891–921

K.J. Falconer [1985]: *The Geometry of Fractal Sets*. Cambridge: Cambridge University Press 1985

Julian F. Fleron [1994]: *A Note on the History of the Cantor set and Cantor Functions*. Mathematics Magazine. **67** 1994: 136-140

Abraham Fraenkel, Yehoshua Bar-Hillel, and Azriel Levy [1973]: *Foundations of Set Theory*. Amsterdam: North-Holland Publishing Company, 2nd edition 1973 (1952):211

Felix Hausdorff [1919]: *Dimension und äußeres Maß*. Mathematische Annalen **79** (1–2) 1919: 157–179

Werner Heisenberg [1927]: *Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik*. Zeitschrift für Physik. 1927, **43**, Nr. 3: 172–198

Albert Abraham Michelson, Edward Morley [1881]: *On the Relative Motion of the Earth and the Luminiferous Ether*. American Journal of Science, 1887, **34** (203): 333–345

Michael C. Stokes [1971]: *One and Many in Presocratic Philosophy*. Center for Hellenie Studies. Cambridge: Harvard University Press 1971

Sir Edmund Whittaker [1949]: *From Euclid to Eddington*. London: Cambridge University Press 1949: 58-60

Wikipedia [2012]: Wikipedia contributors. *Cantor Set*. Wikipedia, The Free Encyclopedia; 2012 February 05, 7:37 UTC. Available from: http://en.wikipedia.org/w/index.php?title=Cantor_set&oldid=486913833

Wikipedia [2012; 2]: Wikipedia contributors. *Planck lengtht*. Wikipedia, The Free Encyclopedia; 2012 March 03, 21:37 UTC. Available from: http://en.wikipedia.org/w/index.php?title=Planck_length&oldid=479757217

Wikipedia [2012; 3]: Wikipedia contributors. *SI base unit*. Wikipedia, The Free Encyclopedia; 2012 March 07, 23:55 UTC. Available from: http://en.wikipedia.org/w/index.php?title=SI_base_unit&oldid=481156172

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Discussion Note

Concept of Universal Balance and Order

Sami M. Angawi [a]*, Karim Daghbouche [b]
[a] Amar International Center For Architectural Heritage, Jeddah (Saudi Arabia)
[b] Hanover (Germany)

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ABSTRACT

In an ever-increasing environment of cultural, economic, and political globalization, the concept of universal balance and order offers a holistic and comprehensive approach to discover the constructive power of fundamental antagonists such as *continuity* versus *change* and *unity* versus *diversity*, which up until today, polarize and disintegrate the world community more dramatic than ever before. In order to sense *equilibrium* and finally reach peace, the underlying principles of the necessary dichotomy of *constancy* and *variation* is exemplarily explored and illustrated in the context of an Islamic concept of universal balance and order, applied on aspects of *Hajj* (Muslim pilgrimage), *Makkah*, and *Madinah*.

Key words: *Makkah, Madinah, Hajj,* continuity, change, unity, diversity, equilibrium

1. INTRODUCTION

Conceptualizing "balance and order" relies on an appropriate analytical framework.

Over the past century, day-to-day perception of the world surrounding us was subjected to various changes, most important of it by a deep revision of common *Cartesian* categories in analytical thought:

1. Complementarity
2. Recursion

1. The concept of *complementarity*, which originated from physical studies describing *quantum mechanical* phenomena at the beginning of last century, proved up until today its heuristics to assess and validate any kind of dichotomies which, in light of physical realities, turn out to be necessary and constructive antagonisms.

While quantum mechanical formalism suggests the impossibility to describe a simple physical system such as "light" without complementary notions like "particle" (photon) and "wave" (electromagnetism) [cf. Bohr 1928], it became evident that any constructive concept of semantically complex notions such as "balance" and "order" calls for thorough analysis of systemic terms like "constant" and "variable".

2. With *complementarity* referring to the way complex phenomena are described, the concept of complexity itself is bound to the way subjective perception materializes in general. With this regard it is important to acknowledge the generic recursive function which lies beneath any complex notion such as

*Corresponding author: s.angawi@gmail.com

beneath the dual pairs “diversity” and “unity”:
Here again quantum mechanical analysis may provide a glimpse on how any measurement necessarily interacts with the object of measurement itself, i.e., how the key interdependence of subject and object can and must be regarded as another fundamental but constructive antagonism. [cf. Bohr 1928]

1.1 The challenge

Any single-sided attempt to provide concepts for “universal order” cannot meet the claim. Classic attempts based on linear causalities not only overlook complementary aspects but also recursive, non-linear realities, which eventually not only represent a theoretical but also a major practical shortcoming. The challenge faced by any approach to overcome the problem lies in providing a balanced solution, which fully anticipates the complexity, non-linearity, and duality of universal systems.

1.2 The approach

This discussion note is an addendum to various projects at *Amar International Center for Architectural Heritage* on subject matter. It briefly elaborates a perspective to satisfy complex universal systems addressing them with an Islamic concept of universal balance and order by applying it on aspects of *Hajj*, *Makkah*, and *Madinah*.

2. FORMAL PART

2.1 Equilibrium

Any synthesis of, e.g., the following dual notions, bears balance [Figure1]:

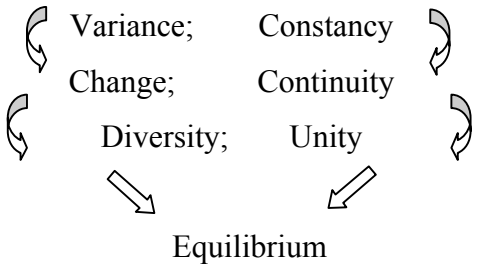

Figure 1

It is evident, that constancy alone could only yield nothing whereas variance alone would lead to chaos.
A balanced order implies “change” *and* “continuity” leading to “diversity” *and* “unity”.
The “Equilibrium” could now be regarded as the balanced interaction of any complementary notion, as well as both, necessarily and sufficiently.

2.2 Order

Having identified an adequate systemic tool with an understanding about seemingly contradictory, dual notions, which eventually turn out to be necessarily complementarities, it is evident that semantically broad conceptions such as “order” should be based on an universal concept of balance which anticipates the fundamental dualities rather than only reposing on one or the other antagonist.
Accordingly, the following practical part emphasizes an Islamic perspective where the syntactically different notions “balance” and “equilibrium” are unified with the semantics of the *Arabic terminus technicus* for “balanced way”. This “balanced way” constitutes the practical imperative for Muslim perception and action as reminded severally by the Islamic prayer schedule.

3. PRACTICAL PART

Applying the concept states of equilibrium and order on *Hajj* and *Makkah*, the identification of their

constants and as a complement, their variables, provides a sense of the underlying principles.
Constants and variables interact as an interdependent system with, e.g., the constants of:

- *orientation* (*Kibla* - universal direction (*Kaaba* - House of *Abraham*) for prayer)
- *area* (sanctuary area around *Kaaba*)
- space (*Al Haram* - Holy Mosque in *Makkah* ← *Kaaba*)
- *point* (black stone in Kaaba)
- *taste* (*Zem Zem* - water source in *Al Haram*)

And variables of:

- *construction* (materials, dimensions, ratios, locations, style)
- *transportation means* (camel vs. car)
- *ethnicity* (diversity: American, Caucasian, Ethiopian, Malayan, and Mongolian)
- *time & culture* (style, pace, traditions, values)
- *technology* (static and dynamic)

4. CONCLUSION

Future city- and landscape planning in *Makkah*, as a Holy City in the center of Muslim´ pilgrimage (*Hajj*), may take advantage of being planned as a true, balanced sanctuary (*Al Haram*) versus an ordinary city as anticipated and ruthlessly executed to-day.
With, e.g., "prayer" being coupled to the *constants* of "orientation", "area", and "space", in addition to the *variable* of "time", city planning should enable pilgrims to pray in exclusive pedestrian areas with appropriate traffic solutions as successfully implemented in many metropolis´ around the world already.
Regarding *Makkah* land- and cityscape planning, it would be advantageous to consider absolute height and the basic ratios of the *Kaaba* for any construction ranging from buildings to tunnels and bridges as it was respected and implemented from the founders´ days (*Abraham*) thousands of years ago, over the first 150 years of *Hidschri* (Islamic (moon) calendar bound to first Muslims exile in *Gregorian* July 622), until the beginning of the past century [Figure 2]:

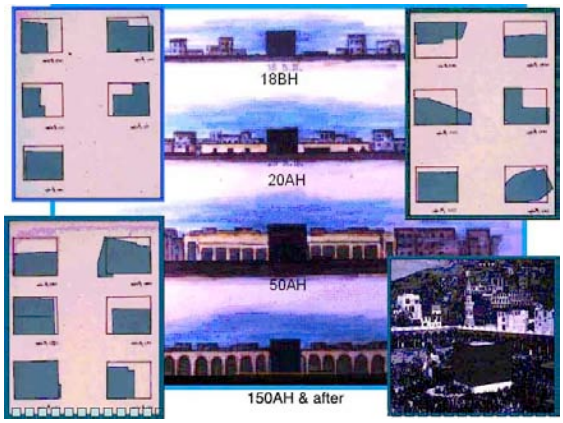

Figure 2

As for the construction height of buildings, the angle to the *Kaaba* should act as a constant value whereas materials would vary according to cultural variance in relation to ethnic diversity. This could be achieved by applying the height angle of the *Kaaba* to the height of constructions and with the surrounding landscape such as mountains as an absolute constant height limit leading to the function of height increase over distance to the *Kaaba* [Figure 3]:

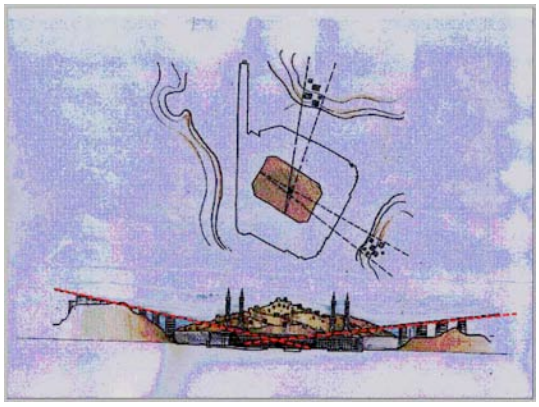
Figure 3

ACKNOWLEDGEMENT

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REFERENCES

Niels Bohr [1928]: *The quantum postulate and the recent development of atomic theory*. Nature. 1928 **121**: 580-59

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Full Length Research Paper

Effects of particulate pollution induced by cement dust on biochemical metabolites in Conifers: *Pinus halepensis* and *Cupressus* sp

Yasmina Dellaa [a,b,c], Chaabane Rahmoune [b], Jacky J. Kister [a], Nathalie Dupuy [a]

[a] Laboratoire des Systèmes Chimiques Complexes, Université Paul Cézanne, UMR 6263, Sce 451, 13397 Marseille cedex 20 (France)
[b] Laboratoire Ecotoxicologie et Stress Abiotiques, Université Mentouri, Faculté des Sciences de la Nature et de la Vie, 25000 Constantine (Algeria)
[c] Institut des Sciences de la Nature et de la Vie, Centre Universitaire de Khenchela, 40000 Khenchela (Algeria)

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ABSTRACT

The subject of this study is around the impact of potential air pollution, possibly attributable to nearby cement factories, on the metabolic mechanisms of trees at five sites in natural medium conditions in the region of Constantine in Algeria. The study focused on the investigation of metabolic changes involved in plants and occurring under a chronic stress caused by dusts. Three biochemical parameters were selected: chlorophylls, proline, and soluble sugars contents. The species selected showed a great sensitivity to continuous exposure. The washing of tree leaves confirmed the existence of deposits thick enough to impair and sometimes prevent exchanges between the plant and the medium, essentially the photosynthesis process. Medium particulate constraints have a determining influence on presented situation of trees, which showed highly significant variations in contents of several metabolites in polluted sites. The plants grown at polluted sites (S2 and S3) showed significant reduction in chlorophylls and soluble sugars. The highest in total Chlorophyll was observed in *Pinus halepensis* (90.84 %) at S2, the lowest reduction (68.53 %) was recorded in *Cupressus macrocarpa* at the same site, but in *Cupressus sempervirens* the reduction was (78.84 %). For proline, plant responses are slightly variable. However, for soluble sugars accumulation, the pollution constraints varied considerably and appeared correlated directly with environmental conditions. The data obtained were further analyzed using one-way Anova and a significant change was recorded in the studied parameters.

Key words: Dust pollution, Biochemical indicators, Cement, Coniferals, Plant stress

1. INTRODUCTION

In Algeria, the notable deterioration of conifers, mainly in the area of Constantine, leads to several assumptions: a) pollution caused by the deposits of cement factory dust localized in the Hamma Bouziane agglomeration; b) the damaging nature of the components of dust; and c) the air pollution caused by the road traffic emiting many pollutants in the atmosphere; associated to deterioration of the leaf areas observed, and the

*Corresponding author: dellaayasmina@yahoo.fr

deterioration of vegetable cover. The deterioration phenomenon of the coniferous plantations was observed in many Algerian forests and applied to up to 20% of the trees. The first senescence was announced approximately 30 years ago, but the deterioration was accelerated since 1985 (Hacène et al., 1995).

In order to use trees to clean polluted air, conifers should be selected for their ability to retain dusts. In this respect, exploiting physiological and morphological traits with an aim to define tolerant species to environmental stress is a prerequisite. Conifers are often considered to be the best temporary biological indicators of a contamination of the environment, because their wood quality reduces the side transfer of the pollutants through the rings (Zayed et al., 1991). The capacity for biochemical defense is an indicator of the potential stress resistance of trees (Tegischer et al., 2002). Of all plant parts, the leaf is the most sensitive part to the air pollutants and several other such external factors (Lalmann and Singh, 1990).

Enhanced accumulation of organic metabolites is a common feature of plants undergoing various biotic and/or abiotic stresses (Khan et al., 2000). Chlorophylls (Chl) are the dominant photosynthetic pigments in green plants and assessment of their concentrations in foliage can provide an estimate of potential photosynthetic capability (Gitelson and Merzlyak, 1996; Carter, 1998). The total Chl. content is a potential indicator of vegetation stress because of its direct role in the photosynthetic processes and its responsiveness to a range of stresses (Gitelson and Merzlyak, 1996, Zarco-Tejada et al., 2002, Rejskova et al., 2007). All the atmospheric pollutants retained by leaves are transformed inside the plant and affect its photosynthesis and respiration. The caused damage appears by chloroses and necrotic lesions at leaves level (Landis and Yu, 1995). Analysis of photosynthetic pigments may therefore provide insight into the physiological status of vegetation (Moran et al., 2000). Therefore, the changes in carbohydrate content as a consequence of exposure to stress may be caused by impaired photosynthesis (Rejskova et al., 2007).

Proline (Pro) accumulation in plants may be part of a general adaptation to adverse environmental conditions (Delauney and Verma, 1993); and has been often reported as a consequence of a wide range of abiotic stresses (Hare et al., 1999; Hong et al., 2000; Klotke et al., 2004; Kishore et al., 2005; Srinivas and Balasubramanian, 1995; Rejskova et al., 2007).

In higher plants, Pro. is synthesized in cytosol either from L–glutamic acid or from L–ornithine (Pavlicova, 2008). Glutamyl kinase and glutamyl phosphate reductase have been proposed to convert glutamate to proline–5–carboxylate. A chloroplast localization of Pyrroline–5–carboxylate reductase enzyme has been reported in pea (Rayapati et al, 1989).

The physiological effect of Pro. accumulation may be expressed in sustained photosynthesis and/or prevention of proteins and enzymes, from degradation (Wang et al., 2007). It can also serve as a rapidly available source of nitrogen, carbon, and reduction equivalents during the recovery from stress (Hellmann et al., 2000). In addition to the stabilizing effects of Prl, stabilizing effects of carbohydrates on membranes and proteins are also accepted (Vereyken et al., 2003).

Carbohydrates are a major category of compatible solutes that include hexoses, disaccharides, sugar alcohols, and complex sugars, all of which are accumulated during stress (Jouve et al., 2004). Sugars play a central role in plant life (Loreti et al., 2001). Sugar alcohols, straight chain polyhydric alcohols constitute an important group of compatible solutes. Mannitol, as polyols is an osmoprotectant and serves as storage compounds and redox agents (Loescher, 1987).

In this work, three spread conifers in the area are selected to study the impact of the particulate air pollution: *Cupressus sempervirens*, *Cupressus macrocarpa* and *Pinus halepensis*. The three biochemical metabolites (Pro., Chl. and sugars) were analyzed according to the chemical species and in various sites with different amount of pollution.

2. MATERIALS AND METHODS

2.1. Study sites

The study was conducted in five sites (S1–S5) selected at various distances from a cement factory of natural medium in the periphery of Constantine in east Algeria (36°30'N, 6°45'E), located at 900 m altitude (Fig. 1). The levels of air pollutants were lowest at S1 site and hence this site was treated as control site for comparing the response pattern observed at sites S2, S3, S4 and S5 respectively. Plant samples were collected next to the cement factory for site S2; within a range of about one kilometer for site S3; 15 km for site S4; 10 km for site S5, and 30 km for site S1, site considered as pilot station.

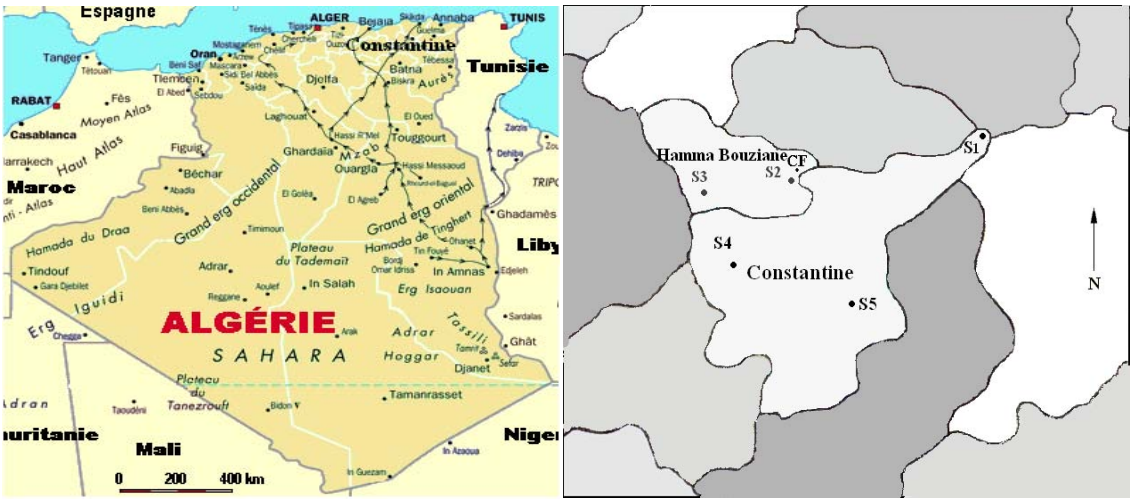

Figure 1: Map of the region of Constantine indicating the different sampling points: Site S1 – Pilot site, located at 30 km, 1325 m altitude, and with no apparent pollution source. Site S2 – Industrial area just near cement factory (CF), located in a depression at 525m altitude. Site S3 – Residential areas. Site 4 – University site and residential area. Site 5 – industrial area near a highway.

The speed of the strongest winds were recorded during April (13.32 km/h) and December (12.24 km/h) when the most frequent winds blow in NW and NNW directions during 25 days. The maximum wind speed was 25.2 km/h (NW) during 4 days although it reached 32 km/h on one occasion. 14.4 to 18 km/h is the maximum speed recorded in direction NNW during 7 days. During

the remainder of the month of April**,** the wind's speed reached 25.2 km/h (NE) although rarely exceeding 18 km/h on average.

These weather conditions are unfavorable for pollutants dispersion in the atmosphere, because generally, the risks are more important when the winds are weak and the air stable. This weather configuration is most frequent in summer in Constantine where the atmosphere is hot, and sunny and slightly weathered fostering a pollution climate. Two sampling campaigns were carried out with a one year interval, the first series in June 2006, and the last one, second series, in July 2007.

The analyses on dust under air pollution effect are done 15 days after the last rains (Harrison et al., 1981).

2.2. Plant material

The study was conducted on *Cupressus sempervirens*, *Cupressus macrocarpa* and *Pinus halepensis* growing under natural conditions. Each conifer's sample consisted of five individual plants collected at selected sites. The reference samples were collected similarly from the control site, without visible sources of pollution and located at 30 km from the cement factory.

2.3. Needles washing technique

In order to measure the importance of the surface deposits, we carried out a washing of the needles, using the Stenbock-Farmer (1978) technique, which recommends solutions of 5 g/l Ethylene Diamine Tetra Acetic Acid (EDTA) pH 2 and 0,1N chlorydric acid pH 2. The number of treatments was often prolonged for up to 5 with duration of washing of 5 minutes. At the end, filters are charged even for the trees needles from the control site. By extending the duration of treatment to 10 minutes, the amount of extracted dust is greater.

2.4. Chlorophyll concentrations measurement

Leaf tissue samples were collected by four repetitions each sample (1g). Chl. contents were determined based on methods recommended by Witham et al. (1971) i.e. by extracting the Chl. using a 10 ml solution made up of 80% acetone and 20% ethanol. The samples were then placed for 48 hours at 30°C to enable extraction in the dark, and then analyzed using a Spectronic 20D spectrophotometer. The Chl. contents were calculated using optical density equations, given by the same authors, at λ=663 nm for Chl ***a***, λ=645 nm for Chl ***b*** and λ=652 nm for total Chl. Results are given in mg/g fresh matter (FM).

2.5. Proline concentrations measurement

To determine the Pro. content we used the Troll and Lindsley (1955) technique, modified by Dreier and Goring (1974).

100 mg of needles FM were taken, by four repetitions each sample and put in test tubes to which 2 ml of methanol 40% were added. The tubes were hermetically closed and heated in a bain-marie at 85°C for 1 hour. After cooling, 1ml from each one is added to 1 ml of acetic acid, 1 ml of reagent (prepared with a mixture of 120 ml distilled water, 300 ml acetic acid and 80 ml orthophosphoric acid), and 25 mg of ninhydrine; the whole is carried to boiling at 95°C for 30 minutes. After cooling, the toluene addition and agitation with the vortex make it possible to distinguish 2 phases: the higher containing Pro. and lower, aqueous, without it. After recovery of the higher phase, 5 mg of oxidized sodium sulphate were added to eliminate moisture. The reading of the

optical density was carried out at wavelength λ=528 nm using a Spectronic 20D spectrophotometer. Results were given in mg/g FM. Standard curves are obtained using L–proline.

2.6. Soluble sugars concentrations measurement

The assay technique of soluble sugars to the anthrone used was that of Shields and Burnet (1960). The Method of measurement of soluble Sgr by anthrone relates mainly to its concentration in reagent (2 g anthrone in 1 liter of sulphuric acid) and to the heating duration. 100 mg of needles fresh matter were taken by four repetitions each sample, put in test tubes in 3 ml ethanol at 80%, and kept at darkness and ambient temperature during 48 hours. In each sample, after evaporation of ethanol, 20 ml of distilled water were added. 2 ml from each sample were put in new tubes, to which we added 4 ml solution with anthrone at 0 °C, in ice bath. The tubes were hermetically closed, and left to mix content, heated in abain-marie for 8 minutes at 90 °C then left 30 minutes in darkness. The reading of optical densities is carried out at wavelength λ=585 nm using a Spectronic 20D spectrophotometer. We obtained Standard curves using D–glucose. Results are given in mg/g FM.

2.7. Statistical analysis

In ecotoxicology, the analysis of variance (Anova) is used to detect differences between groups (Landis and Yu, 1995). In a first instance, biochemical data were analyzed using Sample Power Sample Size (SPSS) 8.0, to calculate Fisher coefficient, classify homogeneous groups with Student Newman Keuils test (SNK) and multiple comparison in order to study the significance of site effect on variables. In second time, we used SYSTAT 5.0 which carries out Anova with multiple regressions (Kenneth et al., 1995). The alphabetical order (**a**, **b**, **c**, **d**, **e**) indicates the growth of the values. The same letter corresponds to different non significant averages. A Principal Component Analysis (PCA) was carried out in order to have correlations between variables and axis.

3. RESULTS

3.1. Results of dust quantification by washing technique

3.1.1. pH of washing solutions

Tables 1 and 2 show the experimental values obtained for pH measurements, and dust weight after washing of the needles. In the majority of treatments, the measured pH could reach values higher than that of the recommended solution (pH 2), suggesting that dust contains compounds playing the part of alkaline plug with values close to neutrality sometimes, thus for EDTA solution of *Pinus* needles at S5 which presents a high capacity of fixing/retention of particles compared to *Cupressus* sp. A pH 7.2 was measured in EDTA solution in 1st treatment of *Pinus* needles at S4 (Tab. 2). At the end of the 5th treatment, pH values generally reach low values. On the other hand, the highest pH values for HCl solution are those found at S2 for *Pinus* needles treatment (pH 2,5). The examination of the data gathered in tables highlights in some sites of the fluctuations between 6.2 at *C. macrocarpa* in S2 and 7.2 at *C. sempervirens* in S3, conversely with the values estimated at pilot site and which did not exceed 2,5 in no case for *C. macrocarpa* and 3.9 for *C. sempervirens* (Tab. 1).

Table 1: pH and dust quantities collected on *Cupressus* verticils in EDTA solution

Sites	*Cupressus sempervirens*			*Cupressus macrocarpa*		
	Washing Number and (mn / trmt)	**pH**	**dust quantities (µg/cm²)**	**Washing Number and (mn / trmt)**	**pH**	**dust quantities (µg/cm²)**
S1			4.20		2.47	4.40
	3	3.97		5	2.25	
		3.96			2.25	
	10	3.99		5	2.31	
					2.23	
S2		**5.80**	9.80		**6.23**	25.20
	5	3.44		5	4.30	
		2.74			3.35	
	5	2.46		5	2.70	
		2.54			2.29	
S3		**7.23**	16.80		**3.71**	5.20
	5	5.30		5	2.47	
		4.35			2.40	
	5	3.70		5	2.35	
		3.29			2.38	
S4	3	2.44	4.80	3	2.45	4.80
		2.43			2.46	
	10	2.43		10	2.42	
S5		2.97	2.54		2.97	3.00
	5	2.34		5	2.34	
		2.27			2.27	
	5	2.27		5	2.27	
		2.31			2.31	

mn / trmt : minute per treatment.

3.1.2. Dust quantification

Following these pH evaluations, the solutions were filtered. The quantities of dust, retained on Millipore filters, informed us that the species with small leaves, such as conifers, are equipped with the capacity of fixing-retention of air particles while contributing to its purification. The winds in Constantine area are not strong enough to allow an important dispersion of the pollutants. This phenomenon contributes to increasing the thickness of the deposits on the leaves.

a. Dust Quantities collected on *Cupressus* needles

On cypresses trees, there was a clear relation between the highest values of pH and the strong tendencies to accumulate important masses of dust, with 25.20 µg/cm² for *C. macrocarpa* and 16.80 µg/cm² for *C. sempervirens* (tab. 1), while the S4 site presents the weakest pH value with few variations between treatments.

The comparison of dust mass deposited on needles shows that in polluted sites, Cypresses have various behaviors. Indeed, under S2 medium conditions *C. macrocarpa* shows a higher Quantitie than the double of that measured at *C. sempervirens* which shows, on the other hand, at S3 a thicker dust mass. But at the other site, these quantities are close (Fig. 2a). Perhaps the exhaust fumes in S3 support the fixing of the deposits on *C. sempervirens* needles.

At S2 and S3 sites, cement factory dusts and roads sides as well as hydrocarbons from road traffic, especially at S5, are strongly deposited and adheres to the leaves, which makes them very difficult

to eliminate during the use of the needles in experimentation.

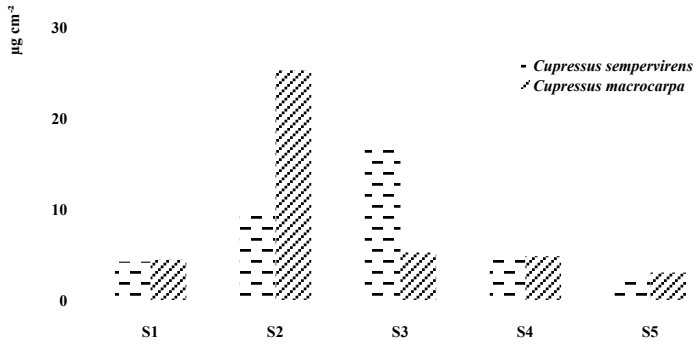

Figure 2a: Dust quantities comparison measured and extracted on *Cupressus sempervirens* and *Cupressus macrocrpa* in EDTA.

b. Dust Quantities extracted on *Pinus halepensis* needles

As illustrated in table 2, we found most important dust mass raised on the foliar deposits using EDTA (104.27 µg/cm²). We could note that the pine at S2 shows a very important capacity of fixing dusts. Compared to the quantity observed at S1, the rate of increase is 97.61%. Similar results were obtained with HCl (Fig. 2b).

Table 2: pH and dust quantities collected on *Pinus halepensis* needles.

Sites	Washing number and (mn / trmt)		pH		Dust quantities extracted by EDTA ($\mu g/cm^2$)
	EDTA	HCl	EDTA	HCl	
S1	3 10	3 10	3.89 3.52 3.73	2.44 2.44 2.43	2.49
S2	5 5	3 10	2.40 2.27 3.20 2.50 2.37	2.43 2.45 2.37	104.27
S3	5 5	3 10	1.63 1.55 2.70 2.70 2.60	1.96 2.41 2.36	27.89
S4	3 10	—	**7.22** 4.23 4.05	—	2.68
S5	3 10	—	6.27 **6.86** 4.43	—	8.77

Thus, it arises from the whole of the results corresponding to the evaluation of dust that the deposits rejected by the cement factory have an important impact on the variation of Chl., Pro. and soluble Sgr. contents mainly at S2, S3 and S5.

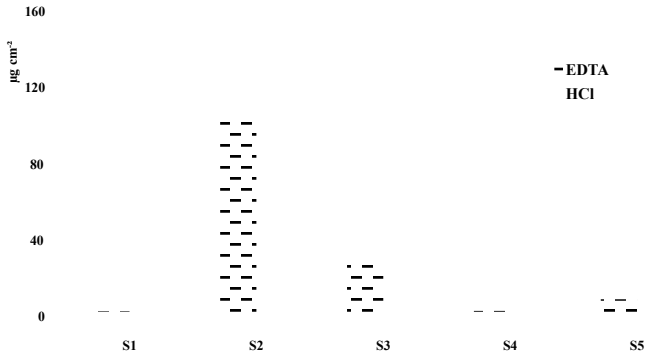

Figure 2b: Dust quantities measured and extracted on *Pinus halepensis* needles.

But, weak precipitations accentuated the phenomenon of pollution and did not contribute to the "rain scrubbing" which is a natural phenomenon of partial elimination of dust, increases the pollutants adsorption on vegetable aerial surfaces and then direct absorption.

3.2. Results of the biochemical analyses

3.2.1. Chlorophyll contents (Chl)

The Chl. contents present great variations between sites and sampling campaigns (Fig. 3A, B,C). All results shows that the pilot site S1 reveals the highest contents, whereas the S2 site, near the cement factory, expresses the lowest contents. Deployed groups by SNK test confirms the results advanced on figures. At S2 and S3 sites, the results of total Chl. contents measurement showed that these contents fall considerably for all species. We notes 5.42±0.46 mg/g FM at *C. semperverens*, which accounts for the 1/5th of S1 content; and 5.52±0.03 mg/g FM for *C. macrocarpa*. It is also valid for *Pinus* (6.23±0.06), which accounts for the 1/10th.

a. *Cupressus sempervirens* and *Cupressus macrocarpa*

At S2, S3 and S5 sites we observed that reduction of total Chl. content is due to an increased matter deposition following permanent exposure to dust effluents. These Chl. contents decrease slightly in S4 at *C. sempervirens* (Fig. 3a); whereas they decrease of more than half at *C. macrocarpa* in S4 (Fig. 3b).

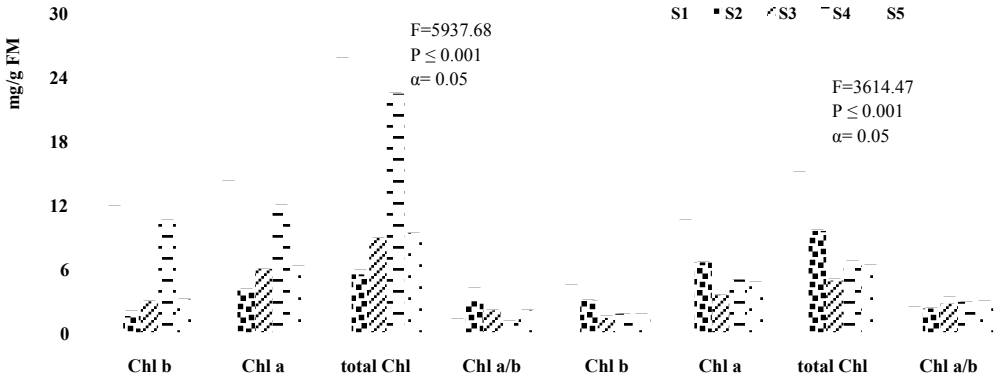

Figure 3a: Chlorophyll contents at *Cupressus sempervirens*. At second sampling series, compared to S1, the reduction of total Chl is estimated at 36.68 % for S2, 67.72 % for S3, 55.62 % for S4, and 58.34 % for S5.

We note also, that *C. macrocarpa* and *C. Sempervirens* do not answer in the same way to an environmental variation at the other sites. Indeed, Chl. ***a*** content at *C. Sempervirens* is about 11.84±0.08 mg/g FM, on the other hand, it approximately lowered half at *C. macrocarpa* at S4 site. At the pilot site (S1), the contents of Chl. ***b*** present an important variation between these two species: 11.59±0.27 mg/g FM for *C. sempervirens* and 6.66±0.24 for *C. macrocarpa*. However, at S2 and S5 sites, Chl. ***b*** contents do not differ as slightly as well at *Cupressus* that at *Pinus*.

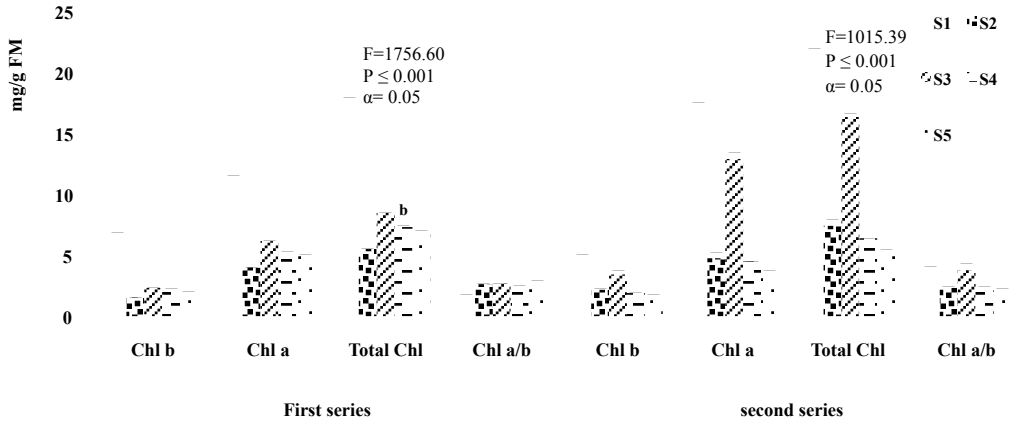

Figure 3b: Chlorophyll contents at *Cupressus macrocarpa*.

Anova for total Chl. at *Cupressus* revealed highly significant differences for the first series and for the second one, whatever considered site, testifying to inter-sites variability; the assumption of equality of the sites averages is rejected**.** Consequently, *C. sempervirens* can be regarded as more resistant to pollution than the other coniferous. While for the second series, SNK test reveal the release of **5** distinct groups indicating the existence of inter-sites differences with a maximum raised at S1 site while being allotted to the group **e** and a minimum recorded at S3, affected to group **a** at α=0.05.

b. *Pinus halepensis*

Chl content for *Pinus* during the 1st series testify to great diversity between sites and an important intra-specific variability. Total Chl content presents some variations when the species are subjected to dust pollution. Indeed, we observed a strong concentration at the pilot site (68.03±0.30), value appreciably close to that recorded in S4 (51.45±0.68) (Fig. 3C). On the other hand, we noticed that the behavior of the Pine seems very different with the fluctuations of medium; it is in S2 that we notes a very important fall of the Chl. content illustrated by the lowest content (6.23±0.06), the rate of fall is estimated at 90.84 %. Between these two limits are the values, considered as rather weak, observed in S3 and S5 where the rate of fall is between 13.08 and 13.58% respectively; resulting in rather close values about 8.90±0.02 and 9.24±0.07 mg/g FM.

With regards to the 2nd series, the Pine shows a similar behavior to that noticed in 1st series for this parameter by showing the highest content at S1, of the intermediate values at S4 and S5 then at S3 and a minimum of accumulation at S2. For this parameter, the Anova revealed highly significant differences (F=2207.23).

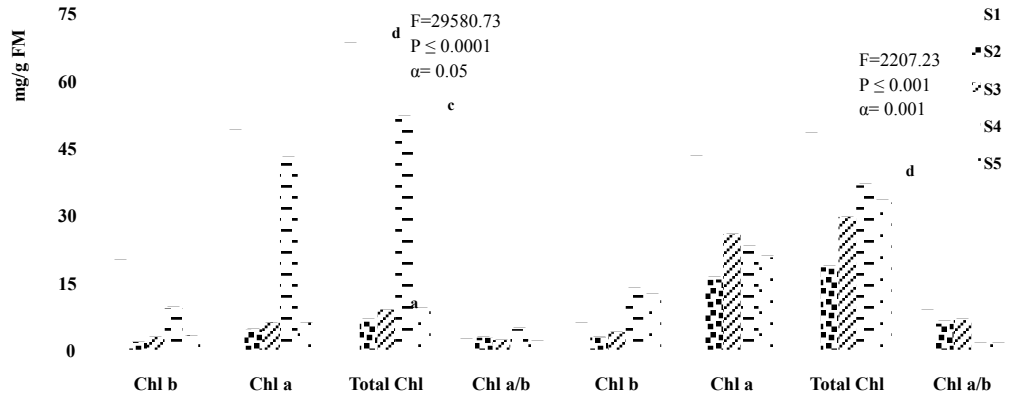

Figure 3c: Chlorophyll contents at *Pinus halepensis*.

The specimens of pine used in experimentation showing that the lowest Chl. contents are located in S2, S3, S5 and present chlorosis and necrosis (Fig. 4 c,f). These observations are on line with those of Wulff et al. (1996) which subjected a species of Pine (*Pinus sylvestris*) with chronic ozone amounts with the aim of estimating the degrees of necrosis and chlorosis observed on the needles. Moreover, these results reveal the significant difference between the sites to have a better photosynthesis and organic matter development.

The layer of "epicuticlar" wax is a characteristic which makes it possible for conifers to survive in adverse conditions, such as temporary dryness, air pollution, wind, high temperatures and strong radiations (Kinnunen et al., 1999). This leads to suppose that this physiomorphologic characteristic is responsible for their apparent resistance to the pollution.

This leads us to deduce that S2 is the most subjected site to pollution by dust deposits and which would require a strong rainfall to eliminate these deposits and to support a regeneration of Chl. biosynthesis to ensure the release of a greater leaf area and a better photosynthesis. It should be noted that Chl. ***a*** content constitute in the majority of cases the double of that in Chl. ***b*** (Lehninger, 1989). This could be explained by the resistance of the species which showed a resilience under pollution in keeping contents minima for the photosynthetic assimilation. The Anova showed that the Site factor explains to 100 % of the variation of the total Chl. content. Chlorophyll contents at S3 site, located at 1 km from the cement factory, displayed slight increases compared to S1, which may demonstrate the direct effect of dust deposits on the inhibition of Chl. biosynthesis. Ali (1993) found that total Chl. content of potted plants transferred to three different sites in Egypt showed a negative correlation with pollution at sites. Clover and mauve developing in increasingly polluted sites had a reduction of total Chl. content up to 29%.

Cypresses are particularly sensitive to the pollution generated by cement dusts (Fig. 4). The low Chl. contents calculated at affected sites illustrate such important reduction. In other terms, the dust quantities emitted and travelling at large distances cause a strong disturbance of Chl. synthesis and result in a metabolic deceleration of the biological processes.

Figure 4: Aspects and comparison between branches of cypress and pine needles coming from the sites near Cement Factory and the pilot site. **a.** *Cupressus* verticils collected at S2 site. **b.** *C. sempervirens* verticils collected at S2 (up) and at S1 (down). c. *Pinus halepensis* needles collected at S1 (left) and S2 (right). d. *Cupressus* verticils collected at S3 (up) and at S1 (down). e. Apical area of cypress branches collected at S1 (left) and at S2 (right). f. Chlorosis on *Pinus halepensis* needles collected at S2

3.2.2. Proline Contents

a. Proline accumulation in *Cupressus sempervirens* and *Cupressus macrocarpa*

For the first series, Pro. contents only slightly vary for *C. macrocarpa* with 0.42±0.01 mg/g FM at S3 and 0.47±0.05 at S1; and are not so different between S2 and S4 (fig. 5). The two cypresses considered behave in the roughly the same manner and present tendencies to have rather close Pro. contents. Whereas for *C. sempervirens*, a strong content was found at site S5 with 0.69±0.01 mg/g FM, which preserves its tolerance character to the stress and where the species are subjected to exhaust fumes and hydrocarbons which seem to play an important part in the activation of Pro. biosynthesis. On sites S2 and S3, contents were above the moderate ones observed varying between 0.36±0.06 at S2 and 0.21±0.03 at S3.

The lowest content observed was in S4 for the 1st series of sampling (Fig. 5). An inter-specific variability was observed with respect to the Pro. accumulation for S5 where we could note that *C. sempervirens* accumulate approximately the double of the content accumulated by *C. macrocarpa*.

For the 2nd series, *C. macrocarpa* revealed little variability and showed a Prl contents brought closer enough (Fig. 5). We note however, the highest content at S4 (0.40±0.11) compared with those reported at S1 (0.34±0.04). No significant difference was

statistically observed with Anova or SNK test. All values were superimposed in a same homogeny group.

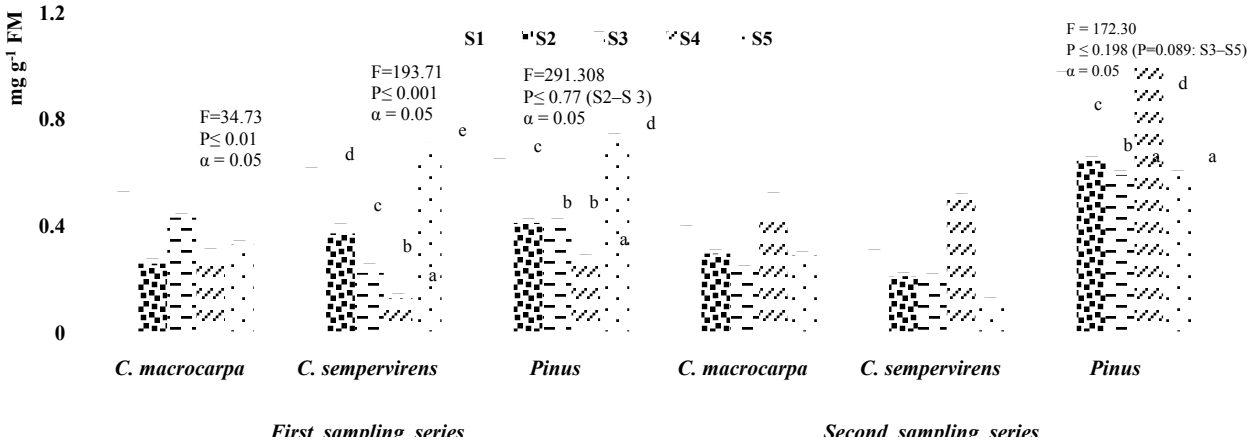

Figure 5: Proline contents.

b. Proline accumulation in *Pinus*

For the 2st series, Pro. content measured at S5 is most important with 0.70±0.03 mg/g FM, value rather close to that observed in S1 (0.64±0.005), against S4 where we could observe the lowest content (0.26±0.02). It is at S2 and S3 that we notes a very low rate of variability for Pro., considering the needles of the pine at these two sites are subjected to comparable deposits of dust, generating the same response of plants to this abiotic stress. This fact was noticed also when taken measurements one year later, during the 2nd series, where we noted that the pine roughly behaves in a similar manner at the sites considered the most polluted, namely: S2, S3 and S5. The Anova reveals highly significant differences (F=291.308, P≤ 0001). The separation of homogeneous groups at α=0.001 distinguish 4 groups. The test of the multiple comparisons of the SPSS at α=0.001 confirms the very high significance of SNK test, except for the Prl contents between S3 and S5 sites which are not significant even at threshold α=0.05 (P=0.089) (Fig. 5).

3.2.3. Soluble sugars contents

a. Soluble sugar contents at *Cupressus*

For the 1st series, we note at *C. sempervirens* that the soluble Sgr. contents are appreciably close and do not present pronounced variations between pilot site S1 and that considered the most subjected to dusts (S2) with respectively 298.97±7.43 mg/g FM and 268.15±2,70 (Fig. 6). A maximum of accumulation was in S5 (453.27±12.60).

A fairly low content is recorded at S4, while the lowest was raised in S3. The strong concentrations recorded out in S5 indicates an activation of the degradation of the glucidic reserves that suggests that a plant adaptation to the constraints of pollution with the risk especially causing an exhaustion of reserves. A rate of fall of the Chl content was noticed, which resulted in a weak development of the organic matter, mainly the glucids.

b. Soluble sugars contents at *Pinus halepensis*

Pinus does not behave in the same manner under the various constraints of sites. However, it had tendencies to have the Sgr. contents most raised at site in the vicinity of the cement factory (S2) for the 1st series with 214.36±2.08 mg/g FM (Fig. 5). Contrary, at the 2nd series, this same site testified to the weakest average (142.90±1.99) (Fig. 6), whereas the maximum value was calculated at S1 (526.33±10.63). Contrary to the weakest Sgr concentrations at S3, appreciably equalizes with that raised in S5, for the 1st series. These sites, crossings both of primary automobile distributors, which suggest that sugars degradation could be activated by the emission of exhaust fumes.

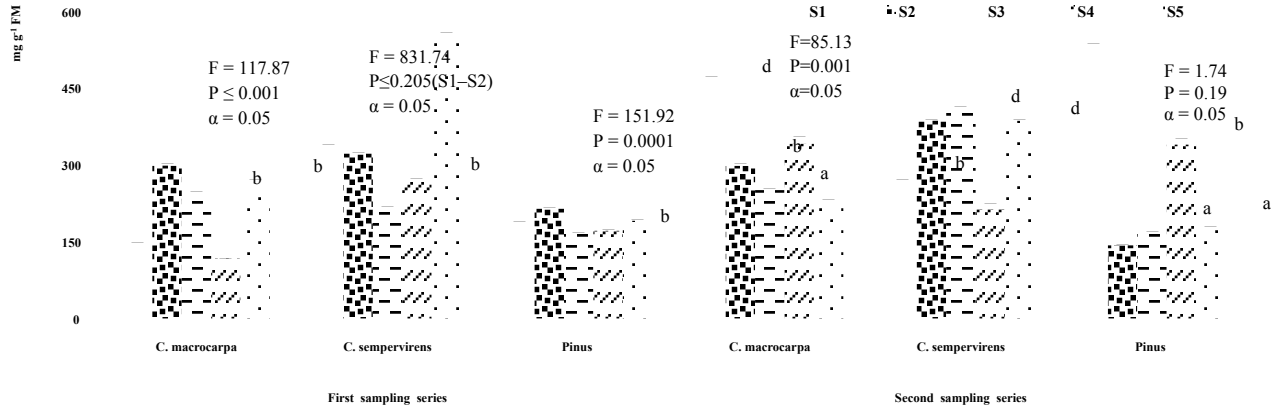

Figure 6: Soluble sugars contents.

The Anova of 1st series results, revealed highly significant differences for soluble sugars and total Chl. accumulation at P≤0.001. Strong soluble Sgr contents in S5 at *C. sempervirens* (Fig. 6) let suppose that pollution would act in two different ways: maybe that it inhibits the activity of the degradation of glucidic reserves or that *C. sempervirens* is not able any more to work out reserves allowing him to adapt to the pollution climate, which supports the assumption of conifers deterioration in the area undergo.

In the pilot site, Sgr. accumulation at *C. macrocarpa* and *P. halepensis* is correlated with Chl. contents and it is inhibited at all other sites where the Chl. is negatively influenced by the deposits of dust. This suggests that the species use the synthesized sugars by photosynthesis in the event of stress. According to Heineke et al. (1992), the soluble Sgr concentrations raised out are proportional to the Pro. cellular contents. In our case, this assertion is not verified since the Pro. and soluble Sgr. contents are very independent in the test of the PCA (Tab. 3). This could be confirmed by the work results of Hellmann et al. (2000) which advances that the biosynthesis of the carboxylate enzyme pyrroline-5 synthétase (P5CS) is induced by the high percentages of Sgr. but which it is inhibited by the proline itself.

Table 3: Correlation matrix between variables and axis in PCA test.

Variables	Chl	Prl	Scr	Axis 1 Correlation	Axis 2 Correlation
Chl	1.000			**0.8558**	0.3086
Prl	**0.605*****	1.000		**0.8970**	0.0629
Scr	0.051	0.202	1.000	0.3435	**-0.9329*****

*** : highly significant

Chl. and Pro. variables are significantly and positively correlated between them and with axis 1 (Tab. 3) and express the tolerance which constitute the first principal component, while there is no significant correlation between Pro. and Sgr. or between Chl. and Sgr. (Tab. 3). In the same way, the soluble Sgr. variable is significantly correlated with the axis 2 whose significance is deterioration and which constitute the second principal component (Fig.7).

Individuals located in the positive part of axis 1 are best adapted to the environmental medium. But, there was no individual from the S2 site (individuals: Cm4, Ph5, Cs6) (Tab. 4) assigned to the groups of people situated on the positive part of axis 1 and 2 (Fig. 7). This may implies that trees from S2 do not tolerate particle deposition and have a poor adaptation. In the main plan (Axis 1 and 2), it seems clear that there are two groups of trees on axis 1 and two groups on axis 2 (Fig. 7).

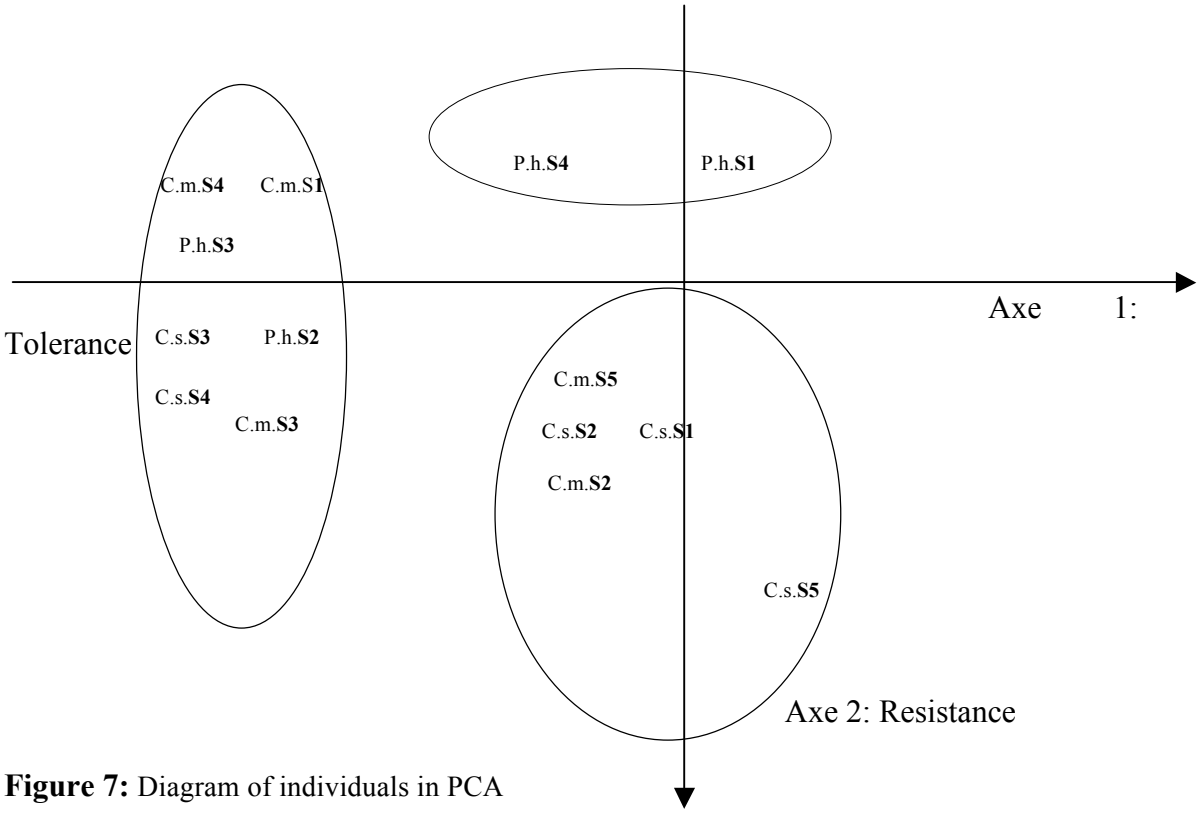

Figure 7: Diagram of individuals in PCA

As axis 1 is mainly formed by the tolerance variables, it would be permitted to say that these groups are positioned relatively to their Chl. and Pro. accumulation; contrary to the groups which are positioned on axis 2 and relatively to their accumulation of soluble sugars.

Table 4: Coding of the individuals in PCA diagram.

	S1	S2	S3	S4	S5
Cupressus macrocarpa	C.m.S1	C.m.S2	C.m.S3	C.m.S4	C.m.S5
Pinus halepensis	P.h.S1	P.h. S2	P.h.S3	P.h.S4	P.h.S5
Cupressus sempervirens	C.s.S1	C.s. S2	C.s.S3	C.s.S4	C.s.S5

4. DISCUSSION

Differentiation of changes in the leaf or needle physiology, through ageing, senescence, accelerated cell senescence, programmed cell death and oxidative stress, provides additional clues raising diagnosis efficiency, especially in combination with information about the target of the stress agent at the tree, leaf/needle, tissue, cell and ultrastructural level (Günthardt-Goerg and Vollenweider, 2007).

The values of pH close to neutrality raised at S2 and S5 could be explained by the existence of limestone and carbonates in the thick foliar deposits of fixed dust. These observations corroborate with those obtained by Kaminski and Landsberger (2000), which observed a pH 7,4 during analyses out of thirteen samples of grounds and aerosols of the area of St Louis where factories are abundant. None of the thirteen samples had a pH<6,5 or >8,0. Results surprising to consider seen that the industry of the area emitted SO_2 which could acidify the layers grounds, the most plausible explanation was that the existence of carbonates in the ground is playing the part of buffer solution.

The winds in Constantine area are not enough strong to allow an important dispersion of the pollutants. This phenomenon contributes to amplify the thickness of the deposits on the needles. These same deposits have an effect on photosynthesis and breathing by clogging the stomata (Laitat, 1990).

Strong mineral acid HCl pH 2 shows an undeniable effectiveness in the dust extraction. This effectiveness varies considerably from species. The present approach, elaborate with an aim of determining the capacity of binding of dust by the plants, highlighted that conifers are species most equipped with this capacity by the important quantities of dust extracted. This phenomenon contributes enormously to the air-cleaning by the foliar system of the trees which absorbs, in addition to the quantities of suspended particles in the air, poisons such as: HF, SO_2, NO_X (Stenbock-fermor, 1978). The EDTA, efficient chealate, is a detergent whose technique of use is regarded as most effective for the dust extraction (Taylor, 1956 cited by Stenbock-Farmer, 1978).

At *Cupressus* and *Pinus*, recognizable damages to a red-brown or yellow-brown coloring of needles were noticed, starting at the end and being able to extend until the base in form of chlorosis which facilitates the detachment of needles (Fig.2). This phenomenon was described by Mulgrew and Williams (2000) under air pollution

conditions and can probably induce early needles senescence.

Changes in Chl contents are an indicator of stress (Naumann et al., 2008). Foliar concentrations of pigments, most notably chlorophylls and carotenoids, are affected by a variety of stress factors (Carter, 1998). In stressed vegetation, leaf Chl content decreases, thereby changing the proportion of light-absorbing pigments and leading to less overall absorption (Zarco-Tejada et al., 2000). The photosynthetic apparatus, especially photosystem II, may be temporarily affected by environmental stresses before irreversible morphological damage is observed (Naumann et al., 2008). Cypress who seems indifferent to pollution by their always green aspect, present morphological apparent damage, following their exposure to a permanent environmental pollution by dust and exhaust fumes. Their contamination is revealed by an apparent change of the foliage color and poor growth, especially when this species are characterized by a fast growth under normal conditions. It was also noticed that the apical buds present a strong inclination and tend to break. This damage is similar to those described following an exposure of conifers to atmospheric pollutants by many authors (Laitat, 1990; Nilsson and Sallinäs, 1999; Mulgrew and William, 2000). The Chl content is weak in the one year old needles of a fir tree presenting of the damage in comparison with a healthy specimen according to a study carried out in three different sites in Germany without correlation with a specific pollutant (Godbold et al., 1993).

The cement factory contributes significantly in the rise of air pollution levels. Great quantities of pulverized materials are handled. Consequently, the major problem of the air pollution lies in the emissions of dust which remains the problem dominating of the environment throughout the world by the movements of the winds constituting a harmful effect with the environment bordering the factory (Debell, 1997).

In response to the varied abiotic stress, several plants accumulate amino acids or their derivatives (Bagni, 1994). For Schwacke et al. (1999), the Prl represents the free amino acid most abundant in the pollen of *Petunia* under conditions of stress. Corroborated the role of Prl in the protection of plants against abiotic stress, as the tolerant line plants, which had higher Prl content, were less damaged, and the sensitive-line plants, with lower Prl levels, suffered greater injury than the tolerant-line plants (Giannakoula et al., 2008).

Sometimes, we note a strong analogy between the total Chl contents and the Prl contents, which appears contradictory, since these two metabolites are in competition for their common precursor, the glutamate (Roosens et al., 1999). Although the dryness was rather marked for the periods of sampling, Prl accumulation is lower than in pilot content, this leads to believe that this metabolite can constitute an indicator of hydrous stress only when the medium does not undergo constraints of the air particulate pollution.

Prl accumulation may be an injury result in plant, rather than an adaptive metabolic response (Qian et al, 2001). These very low Prl contents can inform us that this metabolite could serve, while being degraded, as available and fast source of nitrogen, carbon or reducing equivalents during a stress (Hellmann et al., 2000). Prl accumulates heavily in several plants under stress, providing plants protection against damage by reactive oxygen species and

plays important role in osmoregulation (Ahmad and Hellebust, 1988; Roosens et al., 1999), protection of enzymes (Paleg et al., 1984), enhance antioxidant defense systems in plant responses to oxidative stresses **(**Banu et al, 2009**),** and scavenging of free radicals (Smirnoff and Cumbes, 1989).

Under environmental stress conditions, many plants accumulate several kinds of compatible solutes such as Prl, glycinebetaine, Sgr and polyols (Choudhary et al., 2007).

We could conclude that the activity of the enzyme Pyroline-5-carboxylate synthetase (P5CS) is inhibited during the reaction of the precursor of Prl then supporting the formation of the gluthamine. Extreme sensitivity of the metabolic processes of Prl synthesis and degradation themselves may be of benefit by regulating metabolic processes adversely affected by stress (Hare and Cress, 1997). Although all the species are exposed to a polluted climate, especially in S2, S3 and S5 sites, there is not an important accumulation of free Prl in the needles. Nevertheless, among the studied perennial species, it *Pinus* represent the most accumulating specie of Prl at polluted sites.

Sugar degradation affects the plant metabolism and can lead to retarded plant growth (Sharma, 2009). Contrary to the low Chl contents which thus imply an inhibition of the degradation of Sgr, so a poor adaptation to polluted climate with conservation of plant reserves, and corelation between Chl and Sgr (Fig. 4, 7) and (Fig. 5, 7). For *C. sempervirens*, a simple comparison between Figures, let suppose that this species accumulates more Prl (0.69±0.01) and sugars (453.27±12.60) at S5, which shows that these two metabolites could be influenced by the rejections of exhaust.

Hellmann et al. (2000) showed that a specific increase in Prl is induced by a metabolisable sugars contribution. The vegetable cells can adapt their metabolism to the conditions of pollution by degrading Sgr. A concentration raised out of sugars suggests a good metabolism as the low contents can indicate an imminent lack (Loreti et al*.,* 2001).

An explanation often advanced to justify the increase in pollution by the particulate matters calls upon the increased road transport. Conifers can be selected like better vegetable species to introduce in town or in industrial parks for the air-cleaning.

Plants provide an enormous leaf area for impingement, absorption, and accumulation of air pollutants to reduce the pollutant level in the air environment (Shannigrahi et al*.,* 2004). Schulz et al. (1999) reported that the pine bark surface is very porous and the absence of metabolic processes makes it almost inert for inorganic and organic substances.

5. CONCLUSION

The study related to the foliar widespread forest species system in the urban perimeter of the town of Constantine. Following a continuous exposure to polluted environment, conifers testified to the high significant variations in Chl. contents. The two *Cupresses* who seems indifferent to pollution by their always green aspect and their right port present some morphological apparent damages.

The needles washing technique with acids revealed the existence of thick deposits which make it difficult and sometimes impossible for the plant to conduct natural exchanges with its medium. Chlorophyll Contents observed at *Pinus halepensis* are highly significant due to the existence of an

important intra-specific variability and an inter-sites variation resulting in needles necrosis and chlorosis. Chl ***a*** contents remain relatively higher than those of Chl ***b*** at the polluted sites, and the ratio Chl **a/b** is always higher than 0; this may be results in the weak adaptation of the plant to the stress into spite of its strong total Chl. content (Pääkkönen et al., 1999). Based on these results, the chlorophyll parameter constitutes a good indicator of the particulate atmospheric pollution. *Cupressus* is very sensitive under the same conditions particularly by presenting moderate values. While for Pro., the answers of each plant are very slightly variable. The statistical tests showed very little significance between variations. We attend an inhibition of the synthesis of the amino acid being able to be related to the thickness of dust deposit. Within sight of the fluctuations observed in the Pro. accumulation and the very low contents calculated, this biochemical parameter does not constitute a good factor of tolerance or resistance of the trees to the constraints caused by particulate pollution.

On the other hand, the results of soluble Sgr. analysis presents varied accumulation enough between the various sites. The soluble Sgr. contents are weaker at the particularly exposed sites. Phenomenon probably due to their degradation in the form of energy and under the influence of the polluted medium like resistance and adaptation forms. Soluble Sgr parameter can constitute an indicator of the pollution by the use of Sgr by the plant in maintaining metabolic balance. The statistical analysis proved to be effective to put forward the site effect, plus we move away from the cement factory, conifers accumulate metabolites being used to them as forms of adaptation.

This study showed clearly the repercussions of cement industry localized near the town of Constantine. The trees are very often used for their property as indicators of polluting compounds presence in the ecosphere and, especially for the solid particles, their concentration gradients. Concretely, the air pollution in the periphery of Constantine is alarming and the consequences can be the modification in the climate and the aspect of deterioration of the vegetable cover of the area. The constraints of pollution by the particles have a determining influence on the presented situation of the trees and the strong harmful effects for the population.

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REFERENCES

Ahmad I, Hellebust A (1988). The relationship between inorganic nitrogen metabolism and proline accumulation in osmoregulatory responses of two euryhaline microalgae. Plant Physiol., 88: 348–354.

Ali EA (1993). Damage to plants due to industrial-pollution and their use as bioindicators in Egypt. Environ. Pol., 81 (3): 251–255.

Bagni N (1994). Polyamines as indicators of air pollution. Agri. Med., 124 (00): 1–3.

Banu NA, Hoque A, Watanabe-Sugimoto M, Matsuoka K, Nakamura Y, Shimoishi Y, Murata Y, (2009). Proline and glycinebetaine induce antioxidant defense gene expression and suppress cell death in cultured tobacco cells under salt stress. J. Plant Physiol., 166: 146–156.

Carter GA (1998). Reflectance wavebands and indices for remote estimation of photosynthesis and stomatal conductance in pine canopies. Remote Sens. Environ., 63, 61–72.

Choudhary M, Jetley UK, Khan MA, Zutshi S, Tasneem F (2007). Effect of heavy metal stress on proline, malondialdehyde, and superoxide dismutase activity in the cyanobacterium Spirulina platensis-S5. Ecotoxicol. Environ. Saf., 66, 204–209.

Debell H (1997). Pollution control of cement plant emissions. Air pollution. International Cement Review. Cement Environmental Yearbook'97. Trade ship Publications Ltd, 31–35.

Delauney AJ, Verma DPS (1993). Proline biosynthesis and osmoregulation in plants. Plant J., 4: 215–223.

Dellaa Y, Rahmoune C, Kister J, Dupuy N (2010). Analysis of air pollution aerosols by Raman spectroscopy and spectral resolution methods. XXII International Conference on Raman spectroscopy, Aug 08–13, 2010, Boston, MA. American Institute of Physics Conference Proceedings., 1267: 529–530.

Dreier W, Goring M (1974). Der einflus hoher salzkon zentratimen auf verschieden physiologishe parameter von maïswuzeen. Humboldt-Universität Berlin Naturwissenschaften R., 23: 641–644.

Giannakoula A, Moustakas M, Mylona P, Papadakis I, Yupsanis T (2008). Aluminum tolerance in maize is correlated with increased levels of mineral nutrients, carbohydrates and proline, and decreased levels of lipid peroxidation and Al accumulation. J. Plant Physiol., 165: 385–396.

Gitelson AA, Merzlyak MN (1996). Signature analysis of leaf reflectance spectra: Algorithm development for remote sensing of chlorophyll. J. Plant Physiol. 148: 494–500.

Godbold DL, Freig R, Cremer-herms A, Huttermann A (1993). Determination of stress bioindicators in three Norway spruce stands in northern Germany. Water, Air & Soil Pol. 231p.

Günthardt-Goerg MS, Vollenweider P (2007). Linking stress with macroscopic and microscopic leaf response in trees: New diagnostic perspectives. Environ. Pol., 147 : 467–488.

Hacène H, Mouhous D, Kebbouche S, Lefebvre G (1995). Contribution à la connaissance des dépérissements de la cédraie de Théniet El Had et essais de lutte. Annales de la recherche forestière en Algérie. Institut de la Recherche Forestière. 2ème SEM 94-1er SEM 95, pp. 23–31.

Hare PD, Cress WA (1997). Metabolic implications of stress-induced proline accumulation in plants. Plant Growth and Regulation, 21: 79–102.

Hare PD, Cress WA, Van Staden J (1999). Proline synthesis and degradation: a model system for elucidating stress-related signal transduction. J. Exp. Bot., 50: 413–434.

Harrison RM, Laxen, DPH, Wilson SJ (1981). Chemical associations of lead, Cd, Cu, Zn in Street dusts and roadside soils. American Chemical Society. Environ. Sci. Tec., 15 (11): 1378–1383.

Heineke D, Sonnewald U, Büssis D, Günter G, Leidreter K, Wilke I, Raschle K, Willmitzer L, Heldt HW (1992). Apoplastic expression of yeast-derived invertase in potato. Plant Physiol., 100: 301–308.

Hellmann H, Funk D, Rentsch D, Frommer WB, (2000). Hypersensitivity of an arabidopsis sugar signaling mutant toward exogenous proline application. Plant Physiol., 122: 357–368.

Hong ZL, Lakkineni K, Zhang ZM, Verma DPS (2000). Removal of feedback inhibition of delta (1)–pyrroline–5–carboxylate synthetase results in increased proline accumulation and protection of plants from osmotic stress. Plant Physiol., 122: 1129–1136.

Jouve L, Hoffmann L, Hausman JF (2004). Polyamine, carbohydrate, and proline content changes during salt stress of aspen (Populus tremula L.): involvement of oxidation and osmoregulation metabolism. Plant Biol., 6: 74–80.

Kaminski MD, Landsberger S (2000). Heavy metals soils of East St. Louis, Part I: Total Concentration of Heavy Metal Soils. J. Air & Waste Management Associates. 50, 1667–1679.

Khan AA, McNeilly T, Collins C (2000). Accumulation of amino acids, proline, and carbohydrates in response to aluminum and manganese stress in maize. J. Plant Nutri., 23: 1303–1314.

Kenneth N, Steagall WB, Steagall WJ (1995). Analyse statistique de données avec Student Systat. Windows Version. International Thomson Publishing Company, France, 586p.

Kinnunen H, Laakso K, Huttunen S, Laitat E (1999). Responses to enhanced UV of epicuticular wax and needle morphology in provenances of Pinus Sylvestris L. and Picea abies Karst. Acta Universitatis Ouluensis, 331: 1–16.

Kishor PBK, Sangam S, Amrutha RN, Sri Laxmi P, Naidu KR, Rao KRSS, Rao S, Reddy KJ, Theriappan P, Sreenivasulu N (2005). Regulation of proline biosynthesis, degradation, uptake and transport in higher plants: Its implications in plant growth and abiotic stress tolerance. Curr. Sci., 88: 424–438.

Klotke J, Kopka J, Gatzke N, Heyer AG (2004). Impact of soluble sugar concentrations on the acquisition of freezing tolerance in accessions of Arabidopsis thaliana with contrasting cold adaptation—evidence for a role of raffinose in cold acclimation. Plant Cell Environ., 27: 1395–1404.

Laitat E (1990). Ecophysiologie du pluviolessivage foliaire chez Picea abies (L.) Karst. PhD. Faculté des Sciences Agronomiques, Gembloux, Belgique.

Landis WG, Yu MH (1995). Introduction to environmental toxicology. Impacts of chemicals upon ecological systems. CRC Press, Inc. Boca Raton, USA.

Lehninger AL (1989). Principes de Biochimie. Aminoacides et peptides; La photosynthèse. Flammarion Medecine-Sciences Eds., Johns Hopkins University, Paris, 1001p.

Loescher WH (1987). Physiology and metabolism of sugar alcohols in higher plants. Physiol. Plant 70 : 553–557.

Loreti E, De Bellis L, Alpi A, Perata P (2001). Why and How Do Plant Cells Sense Sugars? Annals Bot., 88: 803–812.

Moran JA, Mitchell KA, Goodmanson G, Stockburger KA (2000). Differentiation among effects of nitrogen fertilization treatments on conifer seedlings by foliar reflectance: a comparison of methods. Tree Physiol., 20: 1113–1120.

Mulgrew A, Williams P (2000). Biomonitoring of Air Quality using Plants. Air Hygiene Report n°10, WHO CC For Air Quality Management and Air Pollution Control.

Naumann JC, Young DR, Anderson JE (2008). Leaf chlorophyll fluorescence, reflectance, and physiological response to freshwater and saltwater flooding in the evergreen shrub, Myrica cerifera. Environ. Exp. Bot., 63 : 402–409.

Nilsson S, Sallinäs O (1999). Pollution atmosphérique et forêts européennes: des modèles de simulation à l'appui des politiques forestières. Forêt et Environnement, 163 : 1–12.

Pääkkönen E, Vahala J, Holopainen T, Karjalainen R, Karenlampi L (1999). Growth responses and related biochemical and ultrastuctural changes of the photosynthetic apparatus in birch (Betula pendula) saplings exposed to low concentration of ozone. Tree Physiol., 16: 597–605.

Paleg LG, Steward GR, Bradbeer JW (1984). Proline and glycine betaine influence proline salvation. Plant Physiol., 75: 974–978.

Pavlikova D, Pavlik M, Staszkova L, Motyka V, Szakova J, Tlustos P, Balik J (2008). Glutamate kinase as a potential biomarker of heavy metal stress in plants. Ecotoxicology and Environmental Safety, 70: 223–230.

Qian YL, Wilhelm SJ, Marcum KB (2001). Comparative Responses of Two Kentucky Bluegrass Cultivars to Salinity Stress. Crop Sci., 41: 1895–1900.

Rayapati, PJ, Stewart, CR, Hack, E, (1989). Pyrroline-5-Carboxylate reductase is in pea (*Pisum sativum* L.) leaf chloroplasts. Plant Physiol. 91: 581–586.

Rejskova A, Patkova L, Stodulkova E, Lipavska H (2007). The effect of abiotic stresses on carbohydrate status of olive shoots (*Olea europaea* L.) under in vitro conditions. J. Plant Physiol., 164: 174–184.

Roosens NH, Willem R, Li Y, Verbruggen I, Biesemans M, Jacobs M (1999). Proline Metabolism in the Wild-Type and in a Salt-Tolerant Mutant of *Nicotiana plumbaginifolia* Studied by 13C-Nuclear Magnetic Resonance Imaging. Plant Physiol., 121: 1281–1290.

Schwacke R, Grallath S, Breitkreuz KE, Stransky E, Stransky H, Frommer WB, Rentsch D (1999). LeProT1, a Transporter for Proline, Glycine Betaine, and γ-Amino Butyric Acid in Tomato Pollen. Plant Cell., 11: 377–392.

Sharma S (2009). Study on impact of heavy metal accumulation in *Brachythecium populeum* (Hedw.) B.S.G. Short communication. Ecol. Ind., 9: 807–811.

Shields R, Burnett W (1960). Determination of protein bound carbohydrate in serum by a modified anthrons. Methods Anal. Chem., 32: 885–886.

Smirnoff N, Cumbes QJ (1989). Hydroxyl radical scavenging activity of compatible solute. Phytochem., 28 : 1057–1060.

Srinivas V, Balasubramanian D (1995). Proline Is a Protein-Compatible Hydrotrope? Langmuir, 11 : 2830–2833.

Stenbock-Farmer K (1978). Mise au point de techniques de lavage de feuilles en vue d'estimer les dépôts de particules. Bulletins of European Research Associates, Bruxelles, 3: 63–75.

Tegischer K, Tausz M, Wieser G, Grill D (2002). Tree and needle age dependent variations in antioxidants and photoprotective pigments in Norway spruce needles at the alpine timberline. Tree Physiol., 22: 591–596.

Troll W, Lindsley J (1955). A photometric method for the determination of proline. J. Biol. Chem., 215: 655–660.

Vereyken IJ, Chupin V, Hoekstrat FA, Smeekens SCM, De Kruijff B (2003). The effect of fructan on membrane lipid organization and dynamics in the dry state. Biophysic J., 84: 3759–3766.

Wang ZQ, Yuan YZ, Ou JQ, Lin QH, Zhang CF (2007). Glutamine synthetase and glutamate dehydrogenase contribute differentially to proline accumulation in leaves of wheat (*Triticum aestivum*) seedlings exposed to different salinity. J. Plant Physiol. 164, 695–701.

Witham FH, Blaydes DF, Devlin RM (1971). Experiments in plant physiology. Van Nostrand Reinhold Company Eds, pp. 51–58.

Wulff A, Anttonen S, Heller W, Sandermann H, Karenlampi L (1996). Ozone sensitivity of scots pine and Norway spruce from northern and local origin to long-term open-field fumigation in central Finland. Environ. Exp. Bot., 36 (2): 209–227.

Zarco-Tejada PJ, Miller JR, Mohammed GH, Noland TL, Sampson PH (2002). Vegetation stress detection through chlorophyll a+b estimation and fluorescence effects on hyperspectral imagery. J. Environ. Qual., 31: 1433–1441.

Zayed J, Andre P, Kennedy G (1991). Variation of Aluminium Levels in Black Spruce (Picea mariana). Water, Air & Soils Pol., 55: 334–337.

TABLE SOURCES

Table Source **Figure 2a**

Site	*C. sempervirens*	*C. macrocarpa*
S1	4,2	4,4
S2	9,8	25,2
S3	16,8	5,2
S4	4,8	4,8
S5	2,54	3

Table Source **Figure 2b**

Site	EDTA	HCl
S1	2,49	11,1
S2	104,27	150,01
S3	27,89	23,016
S4	2,68	
S5	8,77	

Table Source **Figure 3b**

Cuptressus macrocarpa								
	First sampling series				**Second sampling series**			
	Chl b	**Chl a**	**total Chl**	**Chl a/b**	**Chl b**	**Chl a**	**total Chl**	**Chl a/b**
S1	6,6612	10,8771	17,5383	1,619	4,704075	16,784375	21,48845	3,591275
S2	1,5227	3,9977	5,5205	2,627	2,164225	4,7568	7,421025	2,315525
S3	2,3171	6,1674	8,4845	2,6619	3,4242	12,918025	16,367225	3,789625
S4	2,1549	5,1658	7,3207	2,4007	1,894975	4,503825	6,3988	2,377025
S5	1,8758	5,0163	6,8922	2,6866	1,73465	3,69035	5,425	2,131425
σ 1	0,24	0,72	0,47	0,18	0,329278	0,815312	0,505478	0,447747
σ 2	0,043	0,024	0,03	0,086	0,070942	0,458086	0,539465	0,087850
σ 3	0,02	0,05	0,047	0,047	0,349198	0,506524	0,262804	0,549389
σ 4	0,08	0,11	0,11	0,12	0,024094	0,015639	0,018762	0,036271
σ 5	0,14	0,028	0,12	0,22	0,081581	0,050796	0,072905	0,117678

Table Source **Figure 3c**

	First sampling series				**second sampling series**			
	Chl b	**Chl a**	**Total Chl**	**Chl a/b**	**Chl b**	**Chl a**	**Total Chl**	**Chl a/b**
S1	19,7094	48,3285	68,0379	2,4535	5,4158	42,4972	47,913	7,9372
S2	1,7048	4,5291	6,234	2,6619	2,714	15,6283	18,3424	5,7913
S3	2,8337	6,0733	8,907	2,144	3,9024	25,6615	29,564	6,595
S4	9,2127	42,241	51,4537	4,5935	13,6064	22,9654	36,5719	1,6879
S5	3,1597	6,0805	9,4203	1,9249	12,2537	20,5525	32,8062	1,6772
σ 1	0,44	0,69	0,3	0,08	0,65	0,76	0,4	1
σ 2	0,06	0,13	0,66	0,18	0,18	0,67	0,51	0,64
σ 3	0,05	0,03	0,02	0,057	0,23	0,14	0,15	0,43
σ 4	0,41	0,8	0,68	0,26	0,23	0,32	0,51	0,02
σ 5	0,06	0,03	0,07	0,039	0,21	0,35	0,57	0

Table Source **Figure 5**

	First sampling series			**Second sampling series**		
	C. macrocarpa	***C. sempervirens***	***Pinus***	***C. macrocarpa***	***C. sempervirens***	***Pinus***
S1	0,4743	0,5981	0,6419	0,3489	0,3036	0,9123
S2	0,2537	0,367	0,4063	0,2915	0,2069	0,6389
S3	0,4259	0,219	0,4108	0,2336	0,1948	0,5861
S4	0,2749	0,1238	0,2628	0,4093	0,506	0,9969
S5	0,3247	0,6933	0,7084	0,2839	0,1027	0,5861
σ 1	0,05	0,017	0,005	0,046	0,003	0,061
σ 2	0,019	0,037	0,016	0,015	0,013	0,016
σ 3	0,014	0,034	0,013	0,012	0,023	0,017
σ 4	0,037	0,018	0,024	0,11	0,012	0,059
σ 5	0,017	0,016	0,034	0,014	0,025	0,017

Table Source **Figure 6**

	First sampling series			**Second sampling series**		
	C. macrocarpa	*C. sempervirens*	*Pinus*	*C. macrocarpa*	*C. sempervirens*	*Pinus*
S1	134,831	330,26222	183,10095	436,486292	260,934802	526,33548
S2	298,788	322,07478	214,36208	298,256775	386,511005	142,90805
S3	230,178	212,02281	165,23744	250,939745	404,587172	167,78937
S4	116,859	268,16526	171,40460	341,533247	213,511442	339,83196
S5	250,54	544,41165	190,96939	230,524307	386,511005	177,35910
σ 1	12,81	8,931753	5,658534	36,890161	10,541913	10,633037
σ 2	3,65	3,246128	2,083643	5,024978	2,675922	1,994936
σ 3	19,01	5,949435	2,237153	3,330931	9,289973	2,540085
σ 4	1,04	5,260938	1,770753	13,445365	10,915667	12,773815
σ 5	22,04	15,137309	2,024937	1,837601	2,675922	2,55193

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Full Length Research Paper

Testing of Silver Sulphide in Antimony Mineralization Hydrothermal Karst Formations Ain-Kerma

Abderrahmane Toubal [a*], Hicham Chaffai [b], Yves Fuchs [c]

[a] Laboratory of Geology, Badji Mokhtar University, 23000 Annaba, P.O. Box 12 (Algeria)
[b] Laboratory Water Resource and Sustainable Development, Badji Mokhtar University, 23000 Annaba, P.O. Box 12 (Algeria)
[c] Laboratory Geomaterials & environment, IFSA University, Marnes La Vallée (France)

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ABSTRACT

Antimony mineralization of Ain-Kerma are located about 15 km northwest of the city of Constantine, the cottage is located in limestone belonging to the "series Cretaceous neritic Constantine" appearing in the window under post-webs miopliocènes Basin Constantine. Mineralization occupies solution cavities and by extension its origin was held related to karst phenomena. Samples collected from the ore body show, through studies by reflection optical microscopy and SEM, the presence of a silver sulfide: argentite (Ag_2S). This mineral is a good temperature indicator which forms more than 179 °C. His presence and abundance of silica in the matrix of ore provide arguments for classifying this cottage as a hydrothermal karst.

Keywords: Ain-Kerma, lodging, antimony, argentite, hydrothermal karst

INTRODUCTION

The deposit of Ain-Kerma is located some 15 km to the North- West of the city of Constantine (Fig.1), on the South-East flanc of Djebel Kheneg; it was discovered in 1906 and was actively mined from 1913 to 1951, with an overall production of 50 000 tons of cervantite with a mean gade of antinomy of 40%.

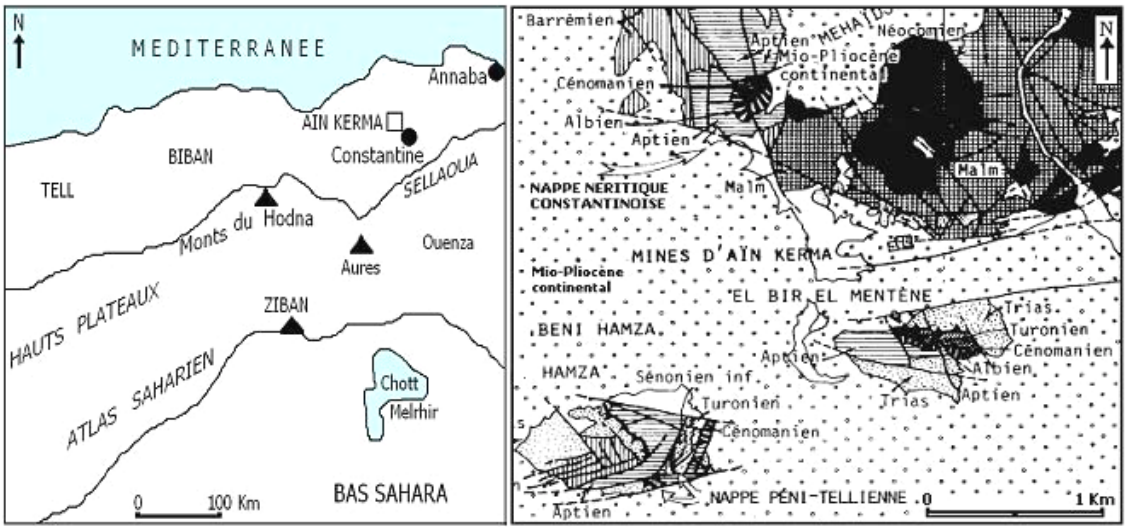

Figure 1 Location map and geology of the area under study

*Corresponding author: toubim@yahoo.fr

GEOLOGY OF THE DEPOSIT

Djebel Kheneg forms a tectonic window outcropping as blocks amid the post-tablecloth series of the basin of Constantine (Vila, 1980). It consists of three major regional structural units, from bottom to top: the neritic series, the tellian series and the post-tablecloth series (Fig. 2), the neritic series being affected by polyphase karsistification as described by many authors (Joleaud, 1918; Vila, 1980).

According to morphology and composition, the mineralization can be classified into three types: fracture deposits, contact deposits and piocket deposits.

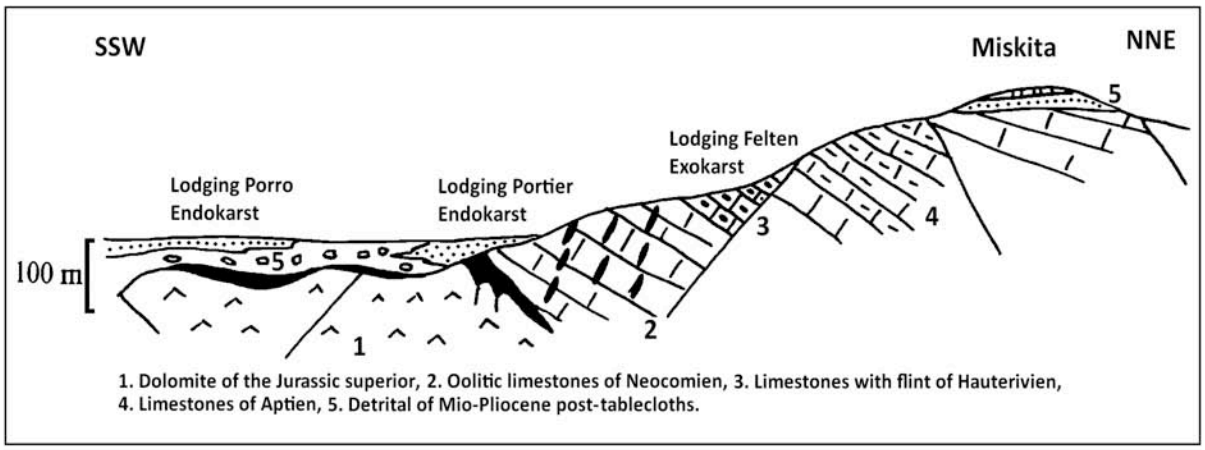

Figure 2 Geological cross-section through the main deposits of Ain- Kerma.

The morphology of the ore bodies is that of a paleokarst ; the fracture deposits are located at the top in the shape of a string of vertical cavities extending to one hundred meter depth, the exokarst , while the contact deposits and the pockets deposits with a horizontal extent, underneath, are associated with the endokarst (Coquette and James,1987). The bottom of the latter is irregular in shape, scratched with many openings in the form of shafts. The roof of the deposit shows collapsed structures in the shape of a dome which was revealed by mining.

MATERIALS AND METHODS

Samples of ore body were collected in the so-called Portier contact deposit; polished sections were made in order to be studied using reflexive metallogenic microscope and SEM at ISTEEM-Montpellier (France).

RESULTS AND DISCUSSION

The ore composition is that of the usual filling of karstic cavities with some detrital elements of the country rocks (elements of limestone and dolomite), carbonate concretions, nodules of stibine partially oxidized and some crystals of quartz (Fig. 3).

Stibine (Sb_2S_3) and its oxide can also have the aspect of small flat slabs few cm in length along the bedding what makes the ore texture look stripped or with a « nougat » aspect. Some nodules of stibine show collapsing structures (Fig. 3 and Fig. 4) which corroborate the non-

consolidated state of the sediments when the mineralization took place (Toubal, 1984) moreover, the occurrence of neoformation quartz in the matrix should be mentioned.

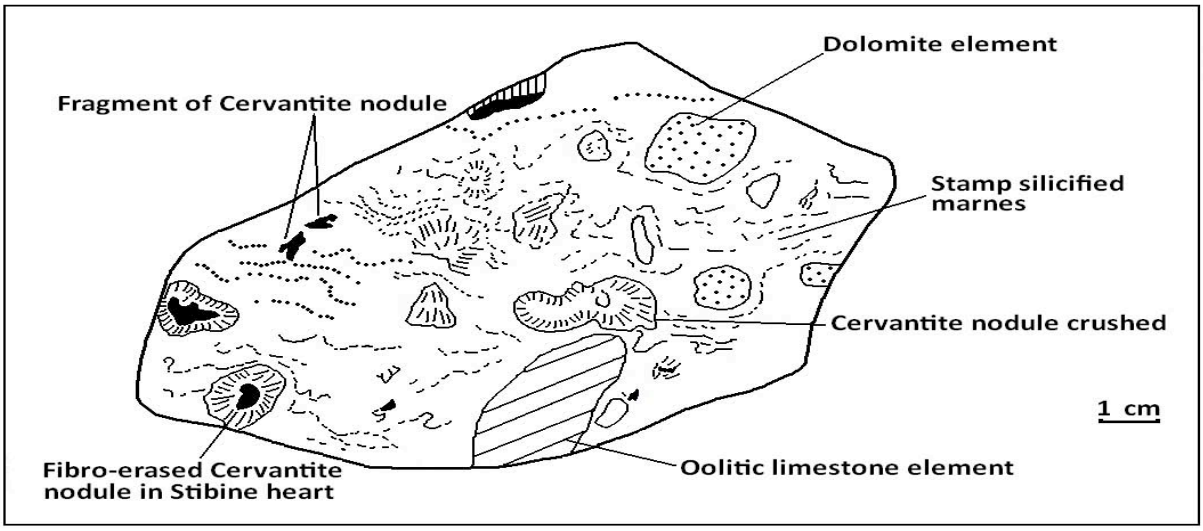

Figure 3 Sample detail of the ore in the main layer of Portier deposit.

Figure 4 Sample from the so- called Portier deposit: intra- karstic filling a- Element of dolomite b- stripped cervantite.

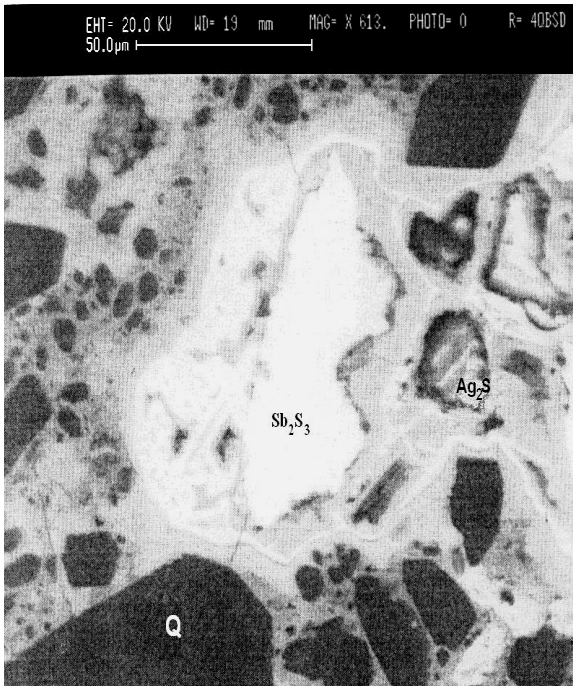

Figure 5 Photos of retrodiffused electron SEM: stibine (Sb2S3), quartz (Q), argentite (Ag_2S).

The other minerals revealed are barytine and silver; in some polished sections, argentite has been recognized by SEM analyses: this mineral occurs as twined lamellous micrigeodes in a siliceous clayey matrix (Fig. 6 and Fig. 7).

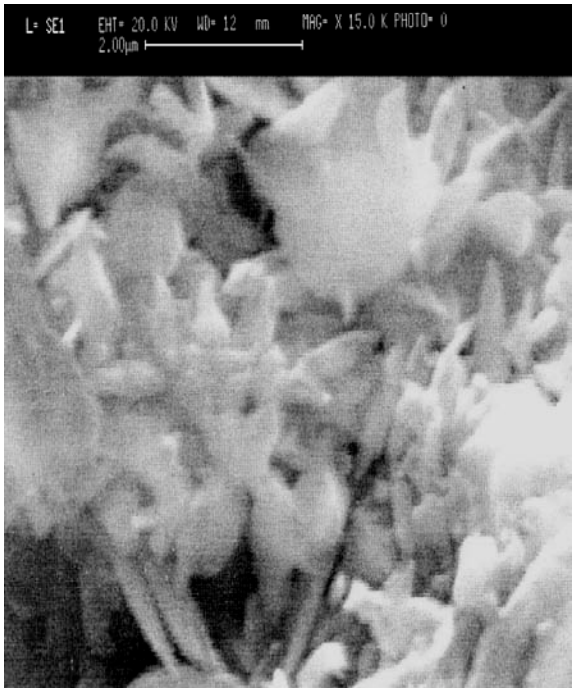

Figure 6 (SEM). Retro diffused electron image: aspect of twined argentite.

Polysynthetic twins are evidence, according to Pico P. 1982, of the reversal of cubic $Ag_2\alpha$ to argentite and then to acanthite. The argentite corresponds to cubic form at temperature above 179°C (Hence, the notion of by hydrothermal karst).

The occurrence of argentite is recognized for the first time, the following observations can thus be made: the paragenesis of antimony deposits of the North-West Algeria is not as simple as previous descriptions suggest. Ain Kerma was thought to be a monomineral deposit (Deleau and Therry, 1953; Toubal, 1984); on the other hand, the occurrence of silver sulfide associated to that of antimony is probably an indication of telescoping phenomena and high temperature conditions. Argentite corresponds to the cubic form at temperature above 179°C, the occurrence of wish may be considered as a good geological thermometer (Picot and Johan 1982).

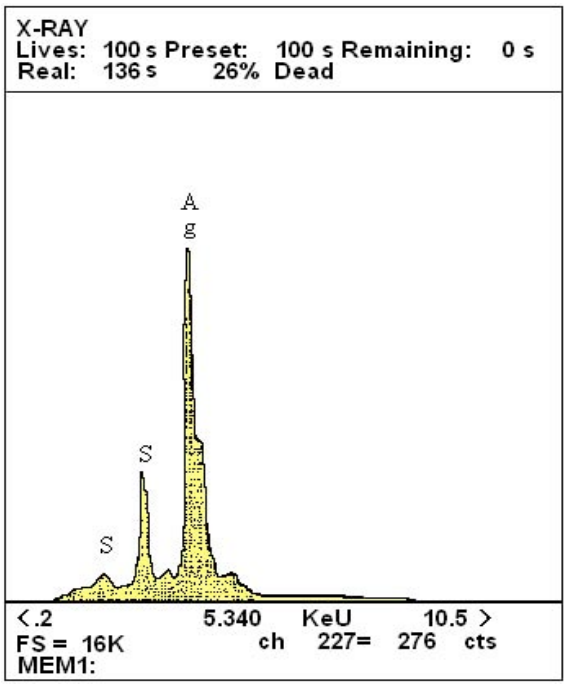

Figure 7 Argentite Spectrum.

5. CONCLUSION

The deposits of Ain-Kerma are related to a karst that developed in a carbonate series of Cretaceous age underneath a Miopliocene unconformity, the karstifications affect a set of cracks, diaclases and reverse faults putting side by side materials of different physicochemical composition (dolomite and limestone).

The ore deposits composition is that of a karst. In the lower parts, the mineralization contains detrital elements from the bottom layer and the roof (limestone, dolomite); precipitations of in situ collomorphe chemical deposits are observed. The ore deposits developing vertically in the upper parts belong to the exokarst while those extending

horizontally in the lower parts belong to the endokarst (Fig. 8).
In Ain-Kerma, there exists also an early mineralization which occurs as nodules of stibine, impregnating still unconsolidated sediment of the karstic felling in a silica-rich matrix. These features are that of a particular karstic environment which is the siege of hydrothermal circulations.

Figure 8. Aspect of karstic felling: collapsing breccias with elements of limestone and dolomite from the roof of the cavity.

The transgressive post-tablecloth formation acted as a screen to the hydrothermal solutions, the mineralization being trapped in the karstic receptacle. The hydrothermalism of the area is related to the Neogene magmatic activity of the North of Algeria (Raoult and Velde, 1971). The deposited silica by thermal solutions lead to the antimony as sulfides (Sb_2S_3); this is the case in most of the indices of the neritic series were siliceous travertine contain thin capillary inclusions of stibine (Toubal 2005). In the English literature, these mineralizations are known as sinters, in Turkey (Bernasconi et al., 1980), New Zealand and USA Nevada (Roberts et al., 1971).
For the first time, the occurrence of silver sulfides (argentite) indicating temperature equal or above 179°C is revealed. The antimony – silver – silica association was pointed out many times in the world, especially in New-Zealand (Krupp and Sewward, 1990). In Tunisia, the occurrence of silver was reported in the karstic cavities (Steinberg and all., 1985). This mineral association is the result of hydrothermalism related to the Neogene magmatism of the North-East of Algeria (Marignac, 1984).
The North-East of Algeria is characterized by a relatively high geothermal gradient (5°/100m on average) due to the thinning of the lithosphere (Kazi-Tani, 1986).
Drilling at depth of 100 to 290m, less than 10km away from Zitouna at the Algerian-Tunisian border, show temperatures above average (1°/30m), exceeding sometimes 1°/10m. On the surface, this geothermal anomaly is revealed by serial hot springs, hammam (Mexa, Sidi Trad, Beni Salah, and Meskoutine), water temperature ranging from 95° to 30°. Data from Geotravers program in Tunisia corroborate the crustal thinning following the rise of the Moho (25 km).

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REFERENCES

Bernasconi, A., Glover, N., and Viljoen, R.P., (1980). The geology and geochemistry of the Senator Antimony deposit-Turkey. Mineral Deposita, 15, 3, PP. 259-274.

Choquette P.W., James N.P., (1987). Introduction in Paleokarst. Ed James and Choquette, Spring-Verlay, pp. 2-21.

Deleau P., Thierry P., (1953). Les gîtes d'antimoine du département de Constantine. Le gîte de Ain -Kerma (étude géologique et minière). Pub. Serv. Géol. Algérie, Trav. Collab. Fasc. 169 p.7 fig.

Joleaud L., (1918). Le rocher de Constantine. In: Annales de Géographie. 1918, t.27n°148. pp. 340-356.

Krupp R., Sewward T.M., (1990). Transport and deposition of metals in the Rotawa Geothermal system in the Zealand. Mineral Deposita 25, 73-81.

Marignac C., (1984). Les minéralisations filoniennes polymétalliques d'Ain Barbar (Algérie): un exemple d'hydrothermalisme lié à l'activité géothermique alpine en Afrique du Nord. Thèse d'Etat Doc. Sc. I.N.P.L. Nancy 1163.p.

Picot P., Johan Z., (1982). Atlas des minéraux métalliques. Mémoires du BRGM. (2è édition).

Raoult J.F. & Velde D. (1971): Découverte de trachytes potassiques à olivine et andésites en coulées dans le Miocène continental du Sud du Kef Haouner (N-E Constantinois). Mém. Soc. Géol. France. Tome L III, N°12, 163 p.

Roberts R.J., Radtke A.J. and Coats R.R. (1971). God bearing deposits in north-central Nevada and southwestern Idaho. Economic Geology, 66: 14-33.

Steinberg M., Rautureau M., Rivière M., (1985). Analyse des argiles zincifères de Tunisie centrale à l'aide d'un microscope à balayage électronique à transmission (tige). Elsevier, Volume 48, Issues1-4, 157-164.

Toubal A., (1984). Contribution à l'étude des minéralisations antimonifères du Nord-Est Algérien : une province métallogénique hétérochrone. Thèse Doct. 3°cycle Paris VI, 141 p.

Toubal A., (2005). Les minéralisations antimonifères et associées du N-E algérien: Etudes gîtologiques, minéralogiques et géochimiques. Comparaison avec les minéralisations de la méditerranée occidentale. Thèse d'Etat, Université d'Annaba, Algérie.

Vila J.M., (1980). La chaîne alpine de l'Algérie orientale et des confins algéro-tunisiens. Thèse de Doctorat d'Etat, Univ. Paris VI, 663 p.

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Full Length Research Paper

Metabolic Diversity of Thermophilic Bacteria from Hot Springs in Algeria

Wahiba Yakhlef *, **Abdelhak Darbouche**

Institute of Biology, Department of Microbiology, University Khenchela (Algeria)

Accepted March 10 2012

ABSTRACT

Hydrothermal samples have been collected from hot springs in the northeast of Algeria (57–98°C). The samples in question are considered as extreme ecosystems. The first spring (57°C) have the highest thermophiles isolation rates. Three thermophilic aerobic strains have been purified. The isolates have an optimum growth temperature of about 45 to 70 °C and pH (6.5 – 8.0).The isolates exhibited extracellular amylase, protease and nitrate-reductase activities at high temperature and showed an antibacterial activity against at least one of the test-bacteria studied using the agar cylinder method. The study of their morphological, physiological and biochemical characteristics suggests that these isolates belong to the genera *Pseudomonas sp., Thermus sp.* and *Geobacillus sp*. Such studies are needed to understand the microbial communities that are native to the hot springs and their interest in biotechnology.

Keywords: Hot springs, thermophily, bacteria, enzymatic activity, antibacterial activity

INTRODUCTION

Many terrestrial hot springs exist on Earth. Thermophilic microorganisms associated with these hot ecosystems have received considerable interest in recent years (Brock, 1978; Kristjansson & Stetter, 1992; Vieille & Zeikus, 2001). Enzymes from these microorganisms also got special attention from the scientist from all over the world since this enzymes resistant to chemical reagents and extreme pH and temperature values in comparison to their mesophilic homologues (Akmar *et al.*, 2011). There are few studies on thermophilic bacteria inhabiting the numerous terrestrial hot springs located in Algeria. *Pyrococcus*, hyperthermophilic *Archaea* and *Caldicoprobacter algeriensis*, xylanolytic thermophilic bacteria, were recently isolated from the North of Algeria (Kesha *et al*., 2007; Bouannane *et al*., 2011).

However, to our knowledge, no thermophilic aerobic species had been already described so far. The main objective of this study was to isolate thermophilic bacteria from hot springs in Guelma, Algeria, and then test their ability to produce thermostable enzymes and antimicrobial agents.

MATERIALS AND METHODS

Sample collection and isolation procedure

Samples were collected from three geothermal hot springs (57–98°C) located in Guelma, northeast of Algeria. Water samples were transported without temperature control and filtered the same

*Corresponding author: wyakhlef@hotmail.fr

day through membrane filters (Gelman type GN-6, pore size 0.45 µm, diameter 47 mm); the filters were placed on the surface of *Thermus* medium (Williams & da Costa, 1992). The plates containing the filters were wrapped in plastic bags and incubated at 55°C for up to 4 days. Cultures were purified by subculturing on *Thermus* medium and were maintained at -70 °C in the same medium with 15% (v/v) glycerol.

Morphological studies

The cellular morphology of strains was examined using light microscopy on cells grown on *Thermus* agar plates for 18h at 55°C. Each agar coated wet mount used for motility observations was prepared by placing 10 ml culture under a cover-glass on a glass slide that had been previously coated with a film consisting of 0.5% (w/v) agarose (Cambrex). Gram staining of strains was determined using the bioMérieux Gram stain kit according to the manufacturer's instructions. Micrographs were taken with a Nikon optishot microscope equipped with a Nikon FX-I1 camera system.

Physiological tests

Determination of the optimum growth temperature

All physiological tests were performed as described previously (Santos *et al*., 1989, Nunes *et al*., 1992). The growth temperature ranges of the strains were examined by measuring the turbidity (610 nm) of cultures incubated at different temperatures (15 to 85°C) in 300 ml Erlenmeyer flasks, containing 100 ml of *Thermus* medium, in a reciprocal water-bath shaker 200 (rpm).

Determination of the optimum pH of growth

The pH range for growth was examined by measuring the turbidity (610 nm) of cultures incubated at 55 °C in the same medium using 20 mM MES for pH values between 5.0 and 6.5, 20 mM Tris for pH values between 7.0 and 8.5, and 20 mM CAPSO [3-(cyclohexylamino)-2-hydroxy-1 propanesulf-onic acid] for pH values upper than 9.0; the pH of each buffer was adjusted with HCl or NaOH. The pH values of the cultures were determined at room temperature. Control media, containing each buffer adjusted to pH 7.5, were used to assess possible inhibitory effects of the buffering agents.

Biochemical tests

The isolates were identified by the use of conventional methods for the presumptive identification by biochemical tests. Oxidase activity was tested using a Bactident Oxidase strip (Merck), whereas catalase activity was determined by bubble production in a 3% (v/v) hydrogen peroxide solution. Hydrolysis of starch, casein, and urea was determined as described by Lanyi (1987). Acid production, by the isolate, from various carbohydrates was characterized using the API kit (bioMérieux) according to the manufacturer's instructions. Denitrification reactions were performed in 5ml nitrate broth tubes includes (gl^{-1}), 25, Brain heart infusion and 10, $NaNO_3$ at pH 7.2. After, inoculation the tubes were sealed and incubated under aerobic conditions at 55°C. All the biochemical tests are listed in Table 2.

Antibacterial activity

Thermophilic isolates were grown on *Thermus* agar plates for 48h at 55 °C. Agar cylinders (3 mm in diameter) were then taken with hollow punch and deposited on the surface of the Mueller–Hinton media (Merck), which had previously been seeded with each test-

bacteria. These last were obtained from the American Type Culture Collection (ATCC); they are two Gram-positive bacteria (*Staphylococcus aureus* ATCC *25923* and *Staphylococcus aureus ATCC 43300*) and two Gram-negative bacteria (*Escherichia coli* ATCC *25922* and *Pseudomonas aeruginosa ATCC 27853*). Plates were kept at 4°C for 4h, then incubated at 37 °C for 18–24 h and the activity of each isolate was estimates by measuring the inhibition zones in (mm). Inhibition zone 2 mm or more were considered as positive result (Aktypis *et al*., 1998; Lemriss *et al.,* 2003).

RESULTS AND DISCUSSION

Hot springs and samples

Three hot springs located in the northeast of Algeria were investigated by collection of three samples of water. Their temperature, pH and chemical composition (data provided by the direction of tourism Guelma; Lahlou *et al.*, 1998; Bouannane *et al*., 2011) determined at the sample site are reported in Table 1.

Generally, the pH of spring waters is neutral, but two of the springs tested were slightly alkaline (spring 1 at pH 7.8 and spring 2 at pH 7.7). Temperatures ranged from 57°C (spring 1) to 98°C (spring 3), which has the highest recorded temperature in Algeria. In this spring; we noted the presence of hydrogen sulfide (H_2S) and arsenic (As).

Isolation of thermophilic bacteria

Sample collected from the spring 1 (57°C) showed the higher rates of thermophiles isolation compared to others springs. However, Spring 3 (98°C) showed the lower isolate rate (Fig. 1). This is not surprising given the fact that oxygen has a low solubility at high temperature and reducing gases are widely present. However, this favors the predominance of anaerobic organisms in these environments (Stetter, 1996; Huber & Stetter, 1998; Adams & Kelly, 1998). Otherwise, many recent molecular studies have shown that hot springs with moderate temperature (55-70°C) have the highest microbial diversity (Lau *et al*., 2006).

Thermophilic bacteria were isolated according to techniques of Williams and da Costa. *Thermus* agar used in this study appeared to adequately support the growth of microbe of hot springs when incubated at high temperature. The isolates grew chemoheterotrophically under aerobic conditions, but no growth was observed under anaerobic conditions.

Characterization and identification of the isolates

The three strains selected were designated STG, SB1 and SDJ. Their morphological, physiological and biochemical characteristics are summarized in Table 2.

Strain STG, isolated from spring 1 (Hammam Ouled Ali, 57°C), formed very short, avoid, Gram-negative, non-motile, rod-shaped cells (Fig. 2). Colonies were smooth and brown. It had an optimum growth temperature between 45 and 55 °C and did not grow at 65 °C (Fig. 3-4). The optimum pH for growth of strain STG was between pH 7 and 7.5.

Strain SB1, isolated from spring 2 (Hammam Belhachani, 72°C), formed long, rod-shaped, non-motile cells that stain Gram-negative. Endospores are not formed. Colonies were yellow pigmented with optimum pH values between 7.5 and 8.0 and an optimum temperature between 60 and 70°C (Fig. 3-4).

Strain SDJ, isolated from spring 3 (Hammam Dbegh, 98°C), formed very long, rod-shaped, mobile, Gram- positive cells. Produce terminally located ellipsoidal spores.

Table 1 Physico-chemical data of the three hot springs.

	Samples		
	1	**2**	**3**
	Hammam Ouled Ali[a]	Hammam Belhachani[b]	Hammam Dbegh[b]
Location	36°30'N / 07°27'E	36°30'N / 07°23'E	36°27'N / 07°16'E
T(°C)*	57	72	98
pH*	7.8	7.7	7.3
Débit (L/s)	20	11	1650
Ca	224	70.2	130
Mg^{2+}	19	33.5	37.4
K^{+}	05	1.3	46
Na^{+}	40	22.3	240
Cl^{-}	ND	31.2	370
SO_4^{2-}	300	171.6	385
HCO_3^{-}	397	nd	183
H_2S	-	-	6.80
As	-	-	0.45

- : absence
nd : not determinate
* : measured *in situ*
[a] : data provided by the direction of tourism Guelma.
[b] : data from (Lahlou M. *et al*., 1998; Bouannane *et al*., 2011)

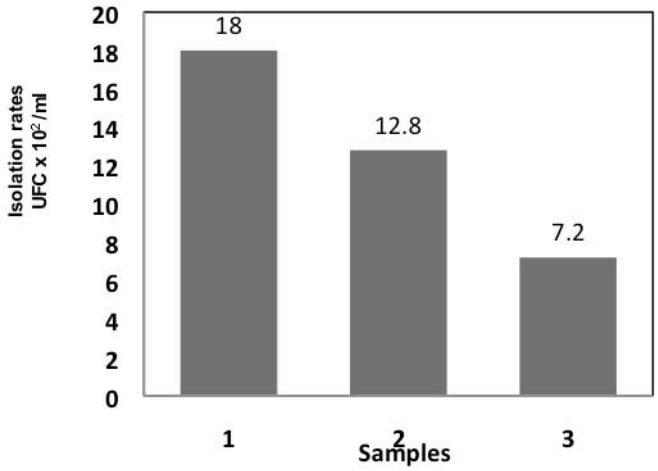

Fig. 1 Thermophiles isolation rates from the three hot springs. 1, from spring 1; 2, from spring 2; 3, from spring 3.

Colonies were mucous, flat, and non-pigmented with a filamentous shape. It had an optimum growth temperature between 50 and 60 °C and an optimum pH values between 6.5 and 7.0 (Fig. 3-4). Consequently, the isolates belong to thermophilic bacteria, because they grew optimally at temperatures up to 50°C, and they have a growth range from 45 to 70°C (Madigan *et al*., 2006). The three strains grow optimally at a pH range from 6.5 to 8.0 and no growth was detected at pH 5 or 9 (Fig. 3-4).

The fact that the Isolates are strictly aerobic microorganisms was further supported by the presence of catalase and oxidase activity for all the isolates.

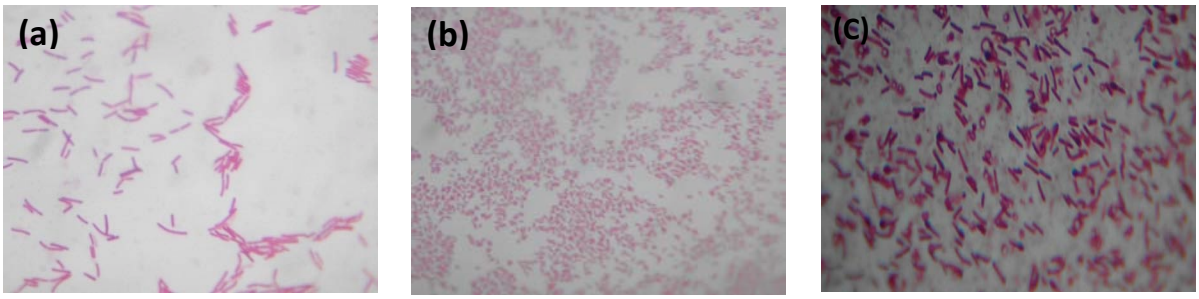

Fig. 2 Gram reaction of the thermophilic isolates. (a), strain SB1 Gram negative (long rods); (b), strain STG Gram negative (avoid rods); (c), strain SDJ Gram positive (long spore formers rods).

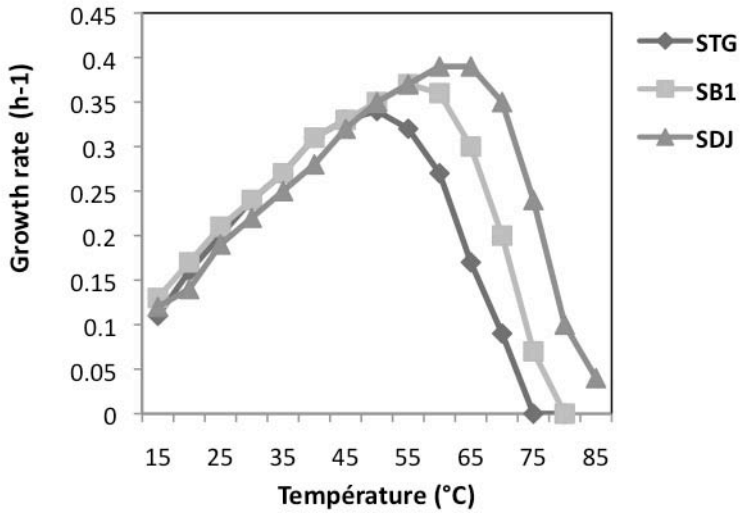

Fig. 3 Effect of temperature on the growth rates of the strains STG, SB1 and SDj.

They were unable to ferment the most of the carbohydrates or polyols examined.

The three thermophilic strains have a proteolytic enzyme that hydrolyzes casein into amino acids. They were also able to hydrolyse strach at high temperatures. Preliminary characterization of these enzymatic activities showed high thermostability, property which could be used in potential biotechnological applications.

Two strains (STG and SDJ) were able to reduce nitrate to nitrite. This ability to denitrify makes them good candidates to actively participate in the global nitrogen cycle within terrestrial hot springs which has been poorly studied so far (Khelifi *et al*., 2010).

The three strains were active against at least one of the tests used bacteria. These results confirm the results of several previous studies that affirm the ability of thermophilic microorganisms isolated from terrestrial hot springs to produce antibacterial substances active against pathogenic microorganisms (Muriana et al., 1991; *Novotny & Perry*, 1992; *Khalil et al.*, 2006). One such area of interest is the use of these bacteriocins in eliminating organisms that are responsible for food spoilage or food-related pathogenicity (*Novotny & Perry*, 1992).

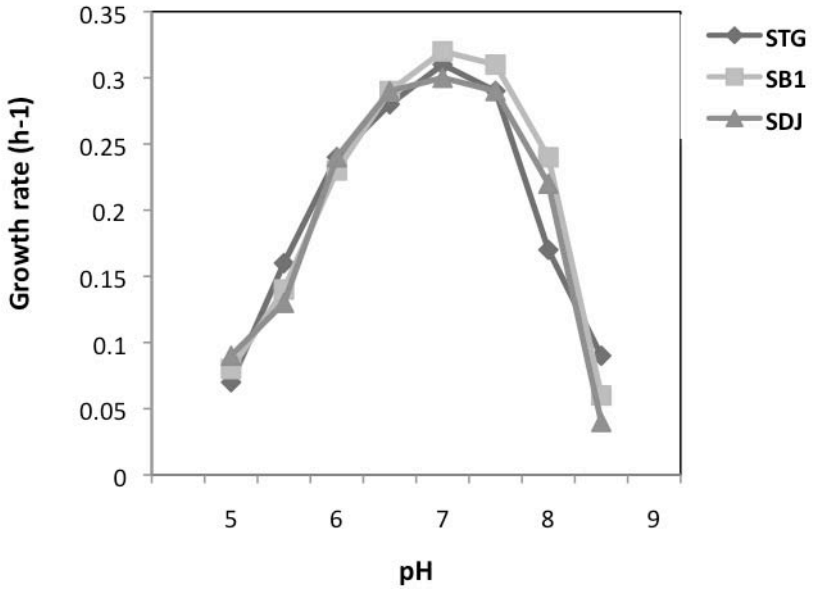

Fig. 4 Effect of pH on the growth rates of the strains SBA, SB1 and SDj.

The study of their morphological, physiological and biochemical characteristics suggest that thermophilic strains STG, SB1 and SDJ belong to the genera *Pseudomonas sp., Thermus sp. and Geobacillus sp.,* respectively (Table 2). These finding were on perfect concordance with the study of Sayeh *et al.*, who have demonstrated a large presence of *Firmicutes* in hot springs with very high temperatures (> 90 °C) However, at lower temperatures springs (50-70°C), members belonging to the *Gammaproteobacteria* subdivision were largely represented.

CONCLUSION

The research of thermophilic bacteria from Algerian hot springs with a temperature rang (57-98°) and pH rang (7.3-7.8) has led to the isolation of three strains that have similar characteristics to the genera *Pseudomonas sp., Thermus sp. and Geobacillus sp.* The isolates grew optimally at temperatures and pH range from 45 to 70°C and from 6.5 to 8.0, respectively. These thermophilic isolates were able to hydrolyze starch and casein at high temperatures, two of them exhibited denitrification reaction, on reducing nitrate to nitrite. The antibacterial activity was detected on the three strains. Finally, the isolation of such strains from Algerian hot springs extends our knowledge on the microbial diversity inhabiting such extreme ecosystems and their interest in biotechnology.

Table 2 Morphological, physiological and biochemical characteristics of the strains STG, SB1 and SDJ.

	STG	SB1	SDJ
Motility	-	-	+
Sporulation	-	-	+
Gram stain	-	-	+
Oxidase	+	+	+
Catalase	+	+	+
Anaerobic growth	-	-	-
Growth at temperature			
45 °C	+	+	+
55°C	+	+	+
65°C	-	+	+
75°C	-	+	+
Growth at pH			
5	-	-	-
7.5	+	+	+
9	+	+	-
Hydrolyse of			
Strach	+	+	+
Casein	+	+	+
Citrate	-	-	-
Denitrification			
NO_3^- ----> NO_2^-	+	-	+
Gas from nitrate	-	-	-
β-galactosidase	-	-	-
Arginine-dihydrolase	-	+	-
Lysine-décarboxylase	-	+	-
Ornithine-décarboxylase	-	+	-
Tryptophane-désaminase	-	-	-
H_2S	-	-	-
Uréase	-	+	-
Indole	+	-	-
Voges-Proskauer reaction	-	-	-
Methyl red test	-	-	-
Gas from glucose	-	-	-
Acid production from			
D-glucose	-	-	-
D-melibiose	-	-	-
D-mannose	-	-	+
L-arabinose	-	-	-
L-rhamnose	-	-	-
Lactose	-	-	-
Sucrose	-	-	+
Inositol	-	-	-
Sorbitol	-	-	-
Amygdaline	-	-	ND
Antibacterial activity			
S. aureus ATCC 25923	+	+	+
S. aureus ATCC 43300	+	+	+
E. coli ATCC 25922	-	-	+
P. aeruginosa ATCC 27853	-	-	+

+, positive result or growth; -, negative result or no growth; ND, not determined.

REFERENCES

Adams MWW & Kelly RM (1998). Finding and using hyperthermophilic enzymes. Trends Biotechnol, (16): 329–332.

Akmar HN, Asma I, Venugopal B, Yoga Latha L & Sasidharan S (2011). Identification of appropriate sample and culture method for isolation of new thermophilic bacteria from hot spring. African Journal of Microbiology Research, (5): 217-221.

Aktypis A, Kalantzopoulos G, Huis JHJ & Brink B (1998). Purification and characterization of thermophilin T: A novel bacteriocin produced by *Streptococcus thermophiles ACA-DC 0040.* Applied Microbiol, (84): 568-576.

Bouanane-Darenfed A, Fardeau L, Grégoire P, Manon J, Kebbouche-Gana S, Benayad T *et al.* (2011). *Caldicoprobacter algeriensis sp. nov*. a New Thermophilic Anaerobic, Xylanolytic Bacterium Isolated from an Algerian Hot Spring. Current Microbiology, (62): 826-32.

Brock TD (1978). Thermophilic Microorganisms and Life at High Temperatures. New York: Springer-Verlag.

Huber H & Stetter KO (1998). Hyperthermophiles and their possible potential in biotechnology. J. Biotechnol, (64): 39-52.

Kecha M, Benallaoua S, Touzel JP, Bonaly B, Duchiron F (2007). Biochemical and phylogenetic characterization of a novel terrestrial hyperthermophilic archaeon pertaining to the genus *Pyrococcus* from an Algerian hydrothermal hot spring. Extremophiles, (11): 65–73.

Khalil AB, Abu zarqa M, Al-Qaryouti M (2006). Production of antimicrobian agents from thermophilic *Yersinia sp.1* and *Aeromonas hydrophila* isolated from hot spring in Jordan Valley, Biotechnology, (5): 252-256.

Khelifi N, Ben Romdhane E, Hedi A, Postec A, Fardeau ML, Hamdi M, *et al.* (2010). Characterization of *Microaerobacter geothermalis gen. nov., sp. nov.,* a novel microaerophilic,nitrate- and nitrite-reducing

Thermophilic bacterium isolated from a terrestrial hot spring in Tunisia. Extremophiles, (14): 297–304.

Kristjansson JK & Stetter KO (1992). Thermophilic bacteria. In Thermophilic Bacteria, (1): 18.

Lahlou Mimi A, Ben Dhia H, Bouri S, Llahrach A, Ben Abidate L, Bbouchareb -Haouchim FZ (1998).

Application of chemical geothermometers springs of the maghreb, north africa. Geothermics, (27): 211-233.

Lanyi B (1987). Classical and rapid identification methods for medically important bacteria. Methods Microbiol, (19): 1–67.

Lau MCY, Jing H, Aitchison JC, Pointing SB (2006). Highly diverse community structure in a remote central Tibetan geothermal spring does not display monotonic variation to thermal stress. FEMS Microbiol Ecol, (57): 80–91.

Lemriss S, Laurent F, Couble A, Casoli E, Lancelin JM, Saintpierre-Bonaccio D, *et al.* (2003). Screening of nonpolyenic antifungal metabolites produced by clinical isolates of actinomycetes. Can J Microbiol, (49): 669–74.

Madigan MT, Martino JM (2006). Brock Biology of Microorganisms (11th ed). Pearson. 136.

Muriana PM, Klaenhammeri TR (1991). Purification and Partial Characterization of Lactacin F, a Bacteriocin Produced by *Lactobacillus acidophilus 11088*. Applied and environmental microbiology, (77): 114-121.

Novotny JF & Perry J (1992). Characterization of Bacteriocins from Two Strains of *Bacillus thermoleovorans*, a Thermophilic Hydrocarbon-Utilizing Species. Applied and Environmental Microbiology, (77): 2393-2396.

Nunes OC, Donato MM & da Costa MS (1992). Isolation and characterization of *Rhodothermus* strains from S. Miguel, Azores. Syst Appl Microbiol, (15): 92-97.

Santos MA, Williams RAD & da Costa M S (1989). Numerical taxonomy of *Thermus* isolates from hot springs in Portugal. Syst Appl Microbiol, (12): 310-315.

Sayeh R, Birrien JL, Alain K, Barbier G, Hamdi M, Prieur D (2010). Microbial diversity in Tunisian geothermal springs as detected by molecular and culture-based approaches. Extremophiles, (14): 501–514.

Stetter KO (1996). Hyperthermophilic procaryotes. FEMS Microbiol, (18): 149-158.

Vieille C & Zeikusb GJ (2001). Hyperthermophilic enzymes: sources, uses, and molecular mechanisms for thermostability. Microbiol Mol Biol Rev, (65): 1-43.

Williams RAD & da Costa MS (1992). The genus *Thermus* and related microorganisms. In The Prokaryotes, 2nd edn; 3745-3753. Edited by A. Balows A, Truper H, Dworkin G, Harder MW & Schleifer KH. New York: Springer-Verlag.