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Variations of Toxicological and biochemical Status in El Ma Labiodh and Ferkan habitants

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ملخص

تتسبب العديد من العوامل البشرية في تلوث الهواء، وخاصة العوامل الصناعية، وهي ظاهرة معقدة للغاية نظرًا لتنوع الملوثات وتأثيراتها.

تعتبر صناعة الأسمنت من أهم مصادر التلوث، خاصة تلوث الهواء الذي يتسبب في انبعاثات الغازات والغبار.

كان الغرض من هذه الدراسة هو تحديد العلاقة بين التعرض للأسمنت وبعض العوامل الأخرى الناتجة عنها , لتقييم نتائج التعرض للأسمنت على صحة سكان مدينة الماء الأبيض.

تحقيقا لهذه الغاية، أجرينا دراسة في العيادة متعددة الخدمات الماء الأبيض وفركان، وشملت هذه الدراسة 160 شخصًا (80 شخصًا تعرضوا للانبعاثات الاسمنتية) و80 شخصً شواهد (فركان) الذين تم اختيارهم عشوائيا.

قمنا بسحب عينات الدم من كل شخص لتحديد مختلف القياسات.

أظهرت نتائج القياسات أن التعرض لانبعاثات الأسمنت يؤدي إلى زيادة في عدد خلايا الدم الحمراء (RBC)والبيضاء(WBC) والصفائح الدموية (PLT) والهيماتوكريت(PCV)، بالإضافة الى ارتفاع في سرعة الترسيب (ERS) وهذا ما يدل على وجود الالتهاب. تقريبا هناك فرق في كل النتائج مقارنة مع الشواهد (سكان فركان).

من خلال هذه الدراسة ، وجدنا أن هناك علاقة كبيرة بين انبعاثات الأسمنت و مختلف القياسات والبيوكيميائية المدروسة وتم ربط هذه الانبعاثات ببعض الأمراض، ولا سيما مرض تصون الرئة، السرطان والربو كما أن الاشخاص المعرضون للانبعاثات الاسمنتية (سكان الماء الأبيض) يعانون أكثر أمراضا من سكان (فركان).

الكلمات المفتاحية: غبار الأسمنت، تلوث الهواء، خلايا الدم الحمراء، خلايا الدم البيضاء.

Abstract

Air pollution caused by many human factors, especially industrial factors This is a very complex phenomenon given the diversity of pollutants and their effects.

The cement industry is one of the major sources of pollution, especially the air pollution it causes gas and dust emissions. The purpose of this study was to determine the relationship between cement exposure and some other factors, Inflammatory parameters used to assess consequences of cement exposure on human health in the City of El Ma Labiodh.

The present study was carried at the multiservice clinic El Ma Labiodh and Ferkan. The study aimed to determine the negative effects of this dust and the continuous exposure to them in hematological and biochemical variables in the blood of 160 subjects (80 controls and 80 people exposed to cement). We draw blood samples from each tester Used to measure various inflammatory parameters. The results of the inflammatory and biochemical parameters showed that exposure to cement emissions lead to an increase in the number of red and white blood cells, platelets and hematocrit, a rise in sedimentation test who is the characteristic of inflammation. Also, the results showed an increase in creatinine, urea, and triglyceride.

These results signify a clear effect on these studied blood components, it is concluded from this study that exposure to cement dust has caused clear negative effects on the blood components, we found that cement emissions are related to various indicators of inflammation studied showing a strong relationship between These emissions have been linked to certain diseases, notably silicosis, cancer and asthma. Indeed, debunked Subjects (El Ma Labiodh population) exhibited more Witnesses (Population of Ferkan).

Keywords: Cement dust; Air pollution; Red Blood Cells (RBCs); White Blood Cells (WBCs).

Résumé

De nombreux facteurs anthropiques sont à l'origine de la pollution atmosphérique, en particulier les facteurs industriels, phénomène très complexe en raison de la diversité des polluants et de leurs effets. L'industrie du ciment est l'une des sources de pollution les plus importantes, en particulier la pollution de l'air qui provoque des émissions de gaz et de poussières. Le but de cette étude était de déterminer la relation entre l'exposition au ciment et certains autres critères. comme variables inflammatoires utilisées pour évaluer les résultats de l'exposition au ciment Santé des résidents d'El Ma Labiodh À cette fin, nous avons mené une étude à la clinique multiservices El Ma Labiodh, qui comprenait 160 personnes (80 personnes exposées aux émissions de ciment) et 80 personnes témoins sélectionnées au hasard. Nous avons prélevé des échantillons de sang de chaque personne pour déterminer diverses mesures inflammatoires. Les résultats des mesures inflammatoires ont montré que l'exposition aux émissions de ciment entraîne une augmentation du nombre de globules rouges et blancs, de plaquettes et d'hématocrites, en plus d'une augmentation de la vitesse de sédimentation, ce qui indique la présence d'inflammation. Presque il y a une différence dans tous les résultats par rapport à la région de Ferkan. Grâce à cette étude, nous avons constaté qu'il existe une relation significative entre les émissions de ciment et les diverses mesures inflammatoires et biochimiques étudiées et que ces émissions ont été liées à certaines maladies, en particulier la préservation pulmonaire et l'asthme, et que les personnes exposées aux émissions de ciment (résidents d'El Ma Labiodh) souffrent de plus de maladies que les résidents de Ferkan.

Mots-clés : poussière de ciment, pollution de l'air, globules rouges, globules blancs.

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I dedicate this modest work to those who, whatever, the terms embraced, I will never manage to express my sincere love.

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ملخص

Abstract

Acknowledgements

Dedications

List of Tables

List of figures

List of symbols

WBC	White Blood cells
LYM	Lymphocytes
RBC	Red Blood cells
HT	Hematocrite
PLT	Platelet Count
GLY	Glycemia
Urea	Uric acid
Crea	Creatinine
TG	Triglyceride
CaO	Calcium oxide
SiO_2	Silicon oxide
Al_2O_3	Aluminium tri oxide
Fe_2O_3	Ferric oxide
MGO	Magnesium oxide
PBFSC	Portland blast furance cement
OPC	Ordinary port land cement
PPC	Port land pozzolana cement
CO_2	Carbon dioxyde
CO	Carbon monoxyde
NOx	Nitrogen oxide
SO_2	Sulfur dioxide
Hcl	Hydrogen chloride
Hf	Hydrogen fluoride
ELV	Emission limit values
Nm3	Concentration of pollutants in the fumes per normal m3
$CaCO_3$	Calcium carbonate
NO_2	Nitrogen dioxide
CLVs	Clovis Oncology Inc Stock Price Quote
Hg	Mercury
Cd	Cadmium
TI	Thallium
ESR	Erythrocyte sedimentation rate

Introduction

Introduction

The cement industry plays a major role in improving living standard all over the world by creating direct employment and providing multiple cascading economic benefits to associated industries. Despite its popularity and profitability, the cement industry faces many challengesdue to environmental concerns and sustainability issues **[10].**

The term pollution, which is widely used today, covers a variety of meanings and defines many acts that degrade the environment.

Air pollution generally refers to the existence of substances in the atmosphere produced by human activities or natural processes in sufficient concentrations for a long enough time to affect people's comfort, health or wellbeing or to change the environment.

Air pollution now is a growing concern for citizens, researchers and governments. This is acurrent problem with adverse effects on the environment and human health. All parts of the environment are affected by air, water and soil.

Air pollution is the most difficult to control. Given the diversity of possible pollutants in the atmosphere, emissions from cement plants in particular are a very complex phenomenon. Although cement is an absolute necessity of social and economic life and highly valued throughout the world, it is itself a polluting element. Therefore, air pollution is the result of the presence in the atmosphere Several pollutants, namely; smoke, gas, liquid or solid particles and other products of simple combustion associated with nuisance, disease, epidemics, environmental aggression, habitat degradation and ecosystem imbalance, global warming, ecological catastrophe and disruption of the climate system.

The cement industry is one of the best structured and distributed industrial activities on the national territory and we thought it interesting to study the impacts of cement exposure on the municipality of Elma Labiod.

To assess the impacts of cement plant operations on human health

- Using the Elma labiod cement factory as an example - we conducted a cross-sectional study with 160 subjects (80 exposed subjects living in Elma labiod and 80 control subjects living in Ferkan).

This study aims to:

- Evaluate the impacts of cement waste on exposed subjects by studying some inflammatory parameters and comparing with control subjects.
- Establish the relationship between cement emissions and these parameters at the

onset of the disease.

To achieve these goals, this work is divided into two parts: The first part is a bibliographic study, divided into two chapters

First Chapter is a literature study on industrial pollution from cement plants and their emissions and their impacts on health and environment.

The second chapter is a bibliographic study on blood, its properties and functions.

The second part deals with the experimental research, mainly presenting Elma Labiod cement industry, the research population and the various results obtained, discussions, conclusions.

Bibliographic part

First Chapter:

Air Pollution in cement works and its environmental impacts

1. Cement industry

The Cement industry is a heavy transformation industry that appeared with the industrial revolution **[27].** It is considered among the strategic industries to be directly linked to building construction works, where natural ingredients are used as raw materials **[43].**

1.1- Cement definition

Cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together **[16].**

. It is a hydraulic gangue hardening quickly and reaches its maximum resistance in a few days. After curing, this paste retains its strength and stability, even under water. It is most frequently used in the form of a powder used with water to aggregate fine sand and gravel to give concrete cement **[52].**

1.2-Compositions

Portland cement consists essentially of compounds of calcium oxide (CaO) (61% - 67%), silicon oxide (SiO_2) (19% - 23%), Aluminum tri oxide (Al2O3), (3-6%), ferric oxide (Fe_2O_3) (2% - 6%), magnesium oxide (MgO) (1% - 2%) 5 and also selenium, thallium and other impurities **[20].**

1.3- Types

Basically, cement is two types, natural and artificial cement. The artificial cement is also called Portland cement

Portland cement is further classified into Portland blast furnace cement (PBFSC), Sulphate Resisting Portland Cement, Ordinary Portland Cement (OPC), Portland Pozzolana Cement (PPC), Rapid Hardening Portland Cement, Oil Well Cement, Clinker Cement, White cement.

Apart from these, some other types of cement available in India can be classified as Low heat cement, High early strength cement, hydrophobic cement, High aluminum cement, and Masonry cement **[20].**

1.4- Cement manufacturing processes and techniques

To manufacture cement, four main elements must be combined according to pre-established dosages:

Lime (65%); Silica (20%); Alumina (10%); Iron oxide (5%). The predominant element is limestone or chalk.

Cement plants are also located near large deposits of these materials.

All of these elements, called raw, are then treated in installations using a wet or dry process, depending on the water content on the limestone or chalk.

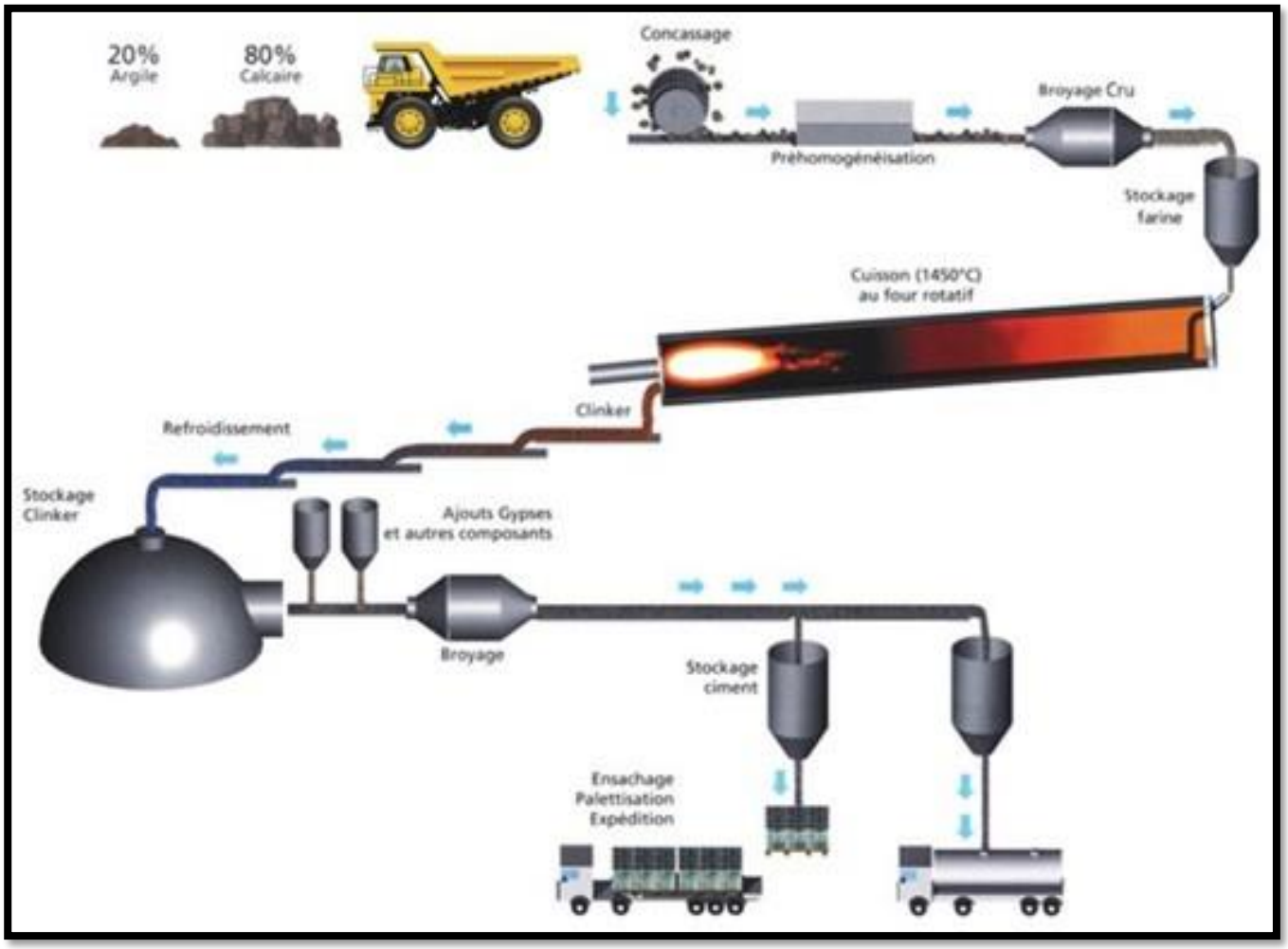

Figure.01: The different stages of cement manufacturing **[48].**

1.4.1- Extraction

For limestone, extraction consists of blasting rock with explosives in open pit quarries to break it up into blocks which are then loaded into dumpers to feed crushers.

While the clay, which is much looser, is mined using excavators or wheel diggers before being transported by trucks **[48].**

1.4.2-Crushing

Materials extracted from quarries (limestone and clay) have coarse grain sizes up to m3.

The crushing, which is most often carried out on the very site of the extraction, aims to limit the particle size to 50, or even 100 mm at most. The crushers used for this purpose can be stationary or mobile **[48].**

Raw material preparation:

Raw milling involves mixing the extracted raw materials to obtain the correct chemical

configuration, and grinding them to achieve the proper particle size to ensure optimal fuel efficiency in the cement kiln and strength in the final concrete product.

1.4.3-TYPES OF PROCESSES

The three important types of processes are

A) Dry Process

In the dry process, the raw materials are dried using impact dryers, drum dryers, paddle-quipped rapid dryers, or air separators, before grinding, or in the grinding process itself.

B) Wet Process

In the wet process, water is added during grinding.

C)Semidry Process

In the semidry process, the materials are formed into pellets with the addition of water in a pelletizing device **[49].**

Figure.02: Raw prehomogenization hall **[48].**

1.5-The cooking

The raw material is then baked in a slightly inclined rotary kiln, the dimensions of which are around 5m in diameter and 80 to 100m in length.

The raw material is introduced into an oven to be baked at a temperature between 1400 and 1500°C. Firing, which generates CO_2 emissions, allows the raw material to be transformed into a clinker **[48].**

Figure.03: Molten material inside a cement kiln **[48].**

1-6-The treatment cycle consists of the following phases

-The preheating takes place in a heat exchanger located upstream of the oven (preheating tower), the hot gases coming from the oven stirring the flour in it against the current;

-The decomposition of clays which is above 500°C;

-The decarbonization of limestone which takes place at 950°C in the middle part of the furnace, the temperatures of which are between 550 and 1000°C;

-The formation of clinker or linearisation at 1450°C which takes place downstream of the kiln near the burner (linearisation zone).

At the end of the firing, the clinker comes in the form of granules the size of a pea or a walnut **[48].**

Figure04: Rotary cement kiln **[48].**

1.6.1-The recooling

The purpose of this operation is to lower the temperature of the clinker, which is around 1200 to 1450°C on leaving the kiln, to around 50/250°C depending on the type of coolers.

Grinding is carried out continuously in grinders fed from clinker stocks and the various constituents and additions **[48].**

The purpose of the grinding is, on the one hand, to reduce the clinker granules to powder, on the other hand, to proceed with the addition of gypsum (whose role is to regulate the setting), as well as that of any other constituents (limestone filler, slag, ashes, etc.), which makes it possible to obtain the different types of standardized cement **[48].**

Figure.05: Cement plant ball mill **[48].**

1.6.2-Storage, bagging, and shipping

From the outlet of the mill, the cement is transported to storage silos, to be either bagged (25 kg or 35 kg bag) or shipped in bulk.

Bagging is done in kraft paper bags using machines capable of filling 2000 to 4000 bags per hour. Bulk delivery is provided by tank trucks, wagons or barges **[48].**

2.-The atmospheric pollution

Air pollution can be defined by the presence of foreign substances or a significant variation in the proportion of its components that are likely to cause harmful effects. It can also be attributed to the presence of impurities in the air or to a chemical and physical modification of the natural environment. Thus, any introduction by man directly or indirectly into the atmosphere of substances is likely to have consequences for human health, harm biological resources and ecosystems, influence climate change, deteriorate material goods or cause odor nuisance, and constitute air pollution **[51].**

2.1-Atmospheric emissions from the cement industry

Air emissions from cement manufacturing are generated by handling and storing intermediate and final materials, and by operating kiln systems, clinker coolers, and crushers.

Many air pollutants can be classified into two large groups: gaseous effluents and particles with variable sizes and compositions (may contain heavy metals).

The dynamic nature of the atmosphere then promotes the transport of these elements and compounds at different spatial and temporal scales.

These pollutants are usually at the heart of the concerns of cement plant operators and technical articles on air pollution and abatement techniques **[54].**

2.1.1-Gaseous pollutants

2.1.1.1-Stack emissions

Dust emissions from chimneys have long been one of the main sources of nuisance for local residents. This is why cement manufacturers have made – for dust as for other pollutants – a lot of effort in recent years.

For several years now, emissions from cement manufacturers have been drastically controlled. The controls concern various pollutants: dust, of course, but also heavy metals, NOx, SO_2, HCl, HF, dioxins and furans, etc. The operating conditions set, in fact, very precisely, the parameters to be measured at the chimney outlet as well as the checks and analyzes to be carried out. These same conditions also determine also “emission limit values” (ELV), expressed as the concentration of pollutants in the fumes per normal m3 (Nm3). Stack emissions are therefore particularly well monitored and controlled **[54].**

2.1.1.2-Emissions of carbon monoxide (CO)

It is a combustible gas, detonating at low concentration, particularly sneaky, toxic and very dangerous by its irreversible effects (It destroys the nerve cells in an irreparable way which can be fatal depending on the concentration and the sustained activity during the inhalation time **[18].**

2.1.1.3-Carbon Dioxide (CO_2) emissions

The cement industry is also a major emitter of greenhouse gases (carbon dioxide – CO_2), coming from the needs for “calorific energy” and also from the cement manufacturing process.

The first source of carbon dioxide emissions is fuel combustion, i.e., the process of physico-chemical combination at very high temperature (energy consumption). This gives us a "direct" energy CO_2.

Another source of CO_2 emissions in cement works is the use of electricity, mainly in grinding plants. This is the "indirect" energy CO_2 (these emissions represent only a small part of the total). And the main source of CO_2 emissions is due to the chemical process “decarbonizations”.

Therefore, the CO_2 produced during the manufacture of cement comes mainly from a phenomenon of transformation of limestone ($CaCO_3$), under the effect of heat in the clinker kiln, into free lime (CaO) and carbon dioxide (CO_2), this is process CO_2 **[13].**

2.1.1.4-Emissions of nitrogen oxides (NOx)

The main nitrogen oxides (NOx) emitted by the cement industry are nitric oxide NO and

nitrogen dioxide NO_2. They have two possible origins:

>A so-called thermal origin. High temperature, atmospheric nitrogen (in the form of N_2) reacts with oxygen in the air to form nitrogen oxides. Therefore, the importance of these emissions depends on the quantity of air injected for combustion and the temperature. By optimizing the temperature and air injection within the limits tolerated by the manufacturing process, the cement manufacturer limits NOx emissions as much as possible. > Fuels. During combustion, the nitrogen contained in the fuels can be transformed into nitrogen oxides by reaction with the oxygen in the air. NOx emissions are therefore also a function of the characteristics of the fuels used.

Here again, the emission limit values are currently being revised. They were until the end of 2005 from 1,200 to 1,800 mg/Nm3 and will be (or are already in some cases) reduced to 800 mg/Nm3. This new limit has already been respected on all sites. The diagram below shows that NOx emissions decreased by 10% between 2001 and 2005. The increase in emissions between 2003 and 2004 can be explained by various factors. Thus, a major change in the fuel recipe at one of the kilns forced the cement manufacturer to increase the injection of air into this same kiln. This caused an increase in thermal NOx emissions. Since then, technical adjustments have been made so as not to be obliged to introduce an “excess” of air into this oven. In addition, strict operating instructions for the furnaces have been applied since 2005 to reduce this impact. To this must be added the drift of a measuring device placed on another furnace which led to a systematic overestimation of the emissions of this furnace (the reported emissions were therefore higher than the actual emissions). These measuring devices have now been replaced by devices more efficient.

Finally, it should be noted that CCB invested in 2005 in a facility to reduce NOx emissions (SNCR type). This installation will reduce the impact of the increased use of alternative fuels **[17].**

2.1.1.5-SO_2 emissions

Sulfur dioxide is the main sulfur oxide emitted by cement plants. These emissions are essentially the consequence of the presence of sulfur in the stone (the presence of pyrite or of organic sulfur) and generally do not depend directly on the combustion of waste. SO_2 emissions are therefore highly dependent on the deposit being exploited, which explains the sometimes-significant differences between the emissions of the various furnaces **[17].**

2.1.1.6-heavy metal emissions

Fuels and raw materials always contain a certain amount of metals, an amount that largely depends on where they come from. Heavy metals and their compounds are generally divided into three classes which depend on their volatility or the volatility of their most common compounds.

> The “ELVs” are defined for each of the following classes:

> mercury Hg;

> cadmium (Cd) and thallium (Tl);

> other heavy metals: Sb, As, Pb, Cr, Co, Ni, Cu,

The analyses carried out in 2004 and 2005 on raw materials, fuels and atmospheric emissions in Belgian cement works show that the heavy metals introduced into cement works kilns mainly come from raw materials and not from fuels. Furthermore, the mass balances show that the sequestration rates of metals in the cement are particularly high: around 87% for mercury, 95% for lead and more than 99% for the other metals. These results confirm the conclusions presented in the "Scientific and technical argument for the reliability of the sector for the recovery of industrial waste and by-products in cement works" drawn up in 1996 within the framework of an agreement concluded between Febelcem and the Walloon Region. This means that the vast majority of heavy metal molecules introduced into clinker kilns end up in the cement, without compromising the quality of the cement and concretes, or the health of those who use them **[17].**

2.1.1.7-Dust emissions

Dust emissions originate mainly from the raw mills, the kiln system, the clinker cooler, and the cement mills. A general feature of these process steps is that hot exhaust gas or exhaust air is passing through pulverised material resulting in an intimately dispersed mixture of gas and particulates. The nature of the particulates generated is linked to the source material itself, that is raw materials (partly calcined), clinker or cement [**49].**

2.1.1.8-Volatile organic compounds

A) Dioxin and furan emissions

Dioxins and furans are polycyclic aromatic chlorinated hydrocarbons and their formation is essentially the consequence of human activities. All combustion processes are potential generators of dioxins and furans: industry using chlorine, high-temperature industrial processes, waste incinerators, domestic heating, transport... and even the burning of a cigarette.

Dioxins and furans can in fact be formed when chlorine and organic compounds are present and brought to favorable temperatures, i.e. to ranges between 250 and 400°C. However, these molecules are destroyed when they are subjected to sufficient temperatures (>850°C), over an adequate period and if the temperature is sufficiently homogeneous. In addition, cooling must be rapid after combustion so as not to lead to reformations. Chlorine and organic matter are present in cement kilns. However, the conditions necessary for the destruction of molecules of dioxins and furans are particularly well met in clinker kilns, in particular, because the temperature there rises to 2,000°C. In addition, the lower temperature zones located downstream of the combustion are also not favorable to the formation of dioxins and furans because the organic precursors have been destroyed when they pass over 1,000°C and the other reagents (HCl and oxygen) are no longer available **[28] [17].**

B) HCl and HF emissions

Chlorine comes from both raw materials and fuels used in cement kilns. It is important to note that nearly 90% of the chlorine introduced into the kilns is integrated into the cement and is therefore not found in the fumes.

Moreover, it can be seen that the emission rate of these compounds is not significantly influenced by the rate of use of waste as fuel. The emission limits imposed on cement plants are derived

from the European directive on the co-incineration of waste. These limits are respected by all cement plants [**28 ; 17].**

2.2-The environmental impacts of air pollution

Air is essential for life, but it can have harmful effects if its quality is poor. Its pollution constitutes an immediate danger for health, the environment, the ecosystem..., it is an effect that amplifies over the years.

According to the World Health Organization (WHO), the estimation of the health impacts of air pollution should include both acute (short-term) and chronic (long-term) effects **[26].**

Epidemiological studies showing a link between ambient concentrations of contaminants and an increase in mortality have not determined a threshold, i.e. a minimum concentration below which there would be no effect. significant. It appears that the relationship between contaminant concentrations and health effects is linear **[36].**

Raw material and Energy consumption result in emissions to air which include dust and gases. The exhaust gases from a cement kiln contains are nitrogen oxides (NOx), carbon dioxide, water, oxygen and small quantities of dust, chlorides, fluorides, sulfur dioxide, carbon monoxide, and still smaller quantities of organic compounds and heavy metals **[30].**

Toxic metals and organic compounds are released when industrial waste is burnt in cement kiln.

Other sources of dust emissions include the clinker cooler, crushers, grinders, and materials-handling equipment **[9].**

These emissions are not only deteriorating air quality but also degrading human health. Emissions have local and global environment impact resulting in global warming, ozone depletion, acid rain, biodiversity loss, reduced crop productivity etc **[23].** Scientific evidence indicates that air pollution from the combustion of fossil fuels causes a spectrum of health effects from allergy to death. The results of several studies showed that these emissions are adversely affecting human health in a variety of ways, like itchy eyes, respiratory diseases like tuberculosis, chest discomfort, chronic bronchitis, asthma attacks, cardiovascular diseases and even premature death **[21].**

NOx causes a wide variety of health and environmental impacts because of various compounds and derivatives in the family of nitrogen oxides, including nitrogen dioxide, nitric acid, nitrous oxide, nitrates, and nitric oxide. Similar to sulphur dioxide, NOx reacts with water and other

compounds to form various acidic compounds. When these acidic compounds that are deposited to the earth's surface, they can impair the water quality of different water bodies and acidify lakes and streams. Acidification (low pH) and the chemical changes result in making it difficult for some fish and other aquatic species to survive, grow, and reproduce. Acid rain can also harm forest ecosystems by directly damaging plant tissues **[39].**

Nitrous oxide is a greenhouse gas and it accumulates in the atmosphere with other greenhouse gasses causing a gradual rise in the earth's temperature. This will lead to global warming and climate change. NOx and volatile organic compounds react in the atmosphere in the presence of sunlight to form ground-level ozone, which causes smog in cities and rural areas. This ground level ozone when breathed, it causes respiratory disease and other health problems **[39].**

Nitrogen dioxide affects body functions such as difficulty in breathing, chronic lung diseases, such as chronic inflammation and irreversible structural changes in the lungs, which with repeated exposure, can lead to premature aging of the lungs and other respiratory illness.

The principal harmful effects of VOCs are toxicity, possible contribution to smog via photochemical reactions in the atmosphere, and possible contribution to the "greenhouse effect" and consequent global warming (Woodard). Dust emissions have been linked to respiratory problems such as Tuberculosis **[49].**

2.3-Climate

Cement manufacture contributes greenhouse gasses both, directly through the production of carbon dioxide when calcium carbonate is heated, producing lime and carbon dioxide, and indirectly through the use of energy, particularly if the energy is sourced from fossil fuels. The cement industry produces about 5% of global man- made CO2 emissions, of which 50% is from the chemical process and 40% from burning fuel. The amount of CO2 emitted by the cement industry is nearly 900kg of CO2 for every 1000 kg of cement produced **[20].**

2.4-Health effects

The health effects of air pollution increase with the concentration of pollutants in the air and the duration of exposure.

Pollutants can act at different levels:

- At the level of the skin: this is particularly the case for irritating vapors and allergy phenomena;
- At the level of the mucous membranes.
- At the level of the pulmonary alveoli.

The pollutants dissolve and pass into the blood or into the superficial liquids, and at the level of the organs. Some toxic blood-borne pollutants can accumulate in organs **[19].**

Table 1 : The effects of different pollutants on health human [72].

EXHIBITION	SYSTEM AFFECTED	HEALTH EFFECTS
Short term	Cardiovascular	Increased rates of myocardial infarction and ischemia in those at risk
	Cardiovascular	Exacerbation of heart failure Increased incidence of arrhythmia
Respiratory		Increased incidence of deep vein thrombosis Increased incidence of stroke Increased wheezing
Long term		Exacerbation of asthma
		Exacerbation of diseases chronic obstructive pulmonary disease chronic Bronchiolitis and other respiratory infections More visits to the to the emergency room Increased mortality Increased number of of myocardial infarctions Accelerated development of atherosclerosis Increased blood coagulability Increase in systemic inflammatory markers Increased incidence of pneumonia
long term	General Cardiovascular	
		Increased incidence of lung cancer
	Reproduction	development in children Increased the incidence of births Premature births Increased incidence of preterm birth Increased incidence of low birth weight

Second Chapter

Blood

1- Generality

Blood is a specialized connective tissue which is fluid in nature. The total volume of blood in human body is about 6 liters. Blood is slightly alkaline with a pH of blood about 7.4. The specific gravity of blood is about 1.055. Blood contains fluid called plasma, in which the cellular elements of blood are suspended **[25].**

Cellular elements of blood are red blood cells (Erythrocytes), white blood cells (leucocytes), and platelets (Thrombocytes). Red blood cells are circular, biconcave, disc shaped. They do not have nucleus and they have a respiratory pigment called Hemoglobin. The normal count of red blood cells in blood is 4.5 to 4.5 million per cu.mm. The main function of red blood cells is transport of oxygen and maintenance of acid base balance. The normal life span of red blood cells is about 120 days **[25].** The red color blood is due to hemoglobin. Adult human hemoglobin consists of four polypeptide chains, two alpha chains and two beta chains **[26].** Hemolysis is the escape of hemoglobin from RBC into blood. This caused by hypotonic condition, certain drugs and toxins. White blood cells are colorless cells containing a nucleus and thus represent the main sources for DNA from the blood. The size of white blood cells is large than red blood cells. The normal white blood cell count in blood is about 8000 per cu.mm. White blood cells are subdivided into two types: granulocytes and agranulocytes. Granulocytes white blood cells have granules in the cytoplasm and they have a nucleus which contains two or more lobes. Granulocytes white blood cells are Neutrophils (60-70%), Eosinophils (2-4%) and Basophils (0.5%). Agranulocytes white blood cells do not have granules and they have a single nucleus which is not lobed. Agranulocytes white blood cells are lymphocytes (25%), monocytes (2-4%). Neutrophils and monocytes protect the body from infection by engulf the bacteria. This process is called phagocytosis. Basophils secrete an anticoagulant substance called heparin. White blood cells are produced immune substance which defends against diseases **[25].**

Platelets are round or oval shaped cells with biconcave surface. The size of the platelets is one fourth of the sizes of RBC. Normal count of platelets is about 2-5 lakh per cu.mm of blood. They do not have any nucleus and cytoplasm contain distinct granules. Platelets play a role in blood clotting, they aggressive at site of vascular and blood vessel injuries **[25].**

Plasma is fluid part of the blood and it contain water (91%), proteins (albumin, globulin, fibrinogen) and other substance like glucose, urea, uric acid, sodium chloride, iron, and

cholesterol. Platelets are transport hormones, iron and other substance. Fibrinogen of plasma is necessary for clotting **[25].**

1.1-definition

The fluid that circulates in the principal vascular system of human beings and other vertebrates, in humans consisting of plasma in which the red blood cells, white blood cells, and platelets are suspended **[78].**

1-2-Physical Characteristics of Blood:

Blood has distinctive physical characteristics:

Quantity: a person has 4 to 6 liters of blood, depending on his size.

Color: The color of arterial blood is bright red because it contains high levels of oxygen, and as for venous blood, its color is darker because it does not contain oxygen.

Degree of Acidity: Normal blood pH ranges from 7.35 to 7.45 and is slightly alkaline. Venous blood usually has a lower pH than arterial blood because it contains carbon dioxide **[7].**

Viscosity: Viscosity increases with the presence of blood cells and plasma proteins, and this thickness contributes to normal blood pressure **[55].**

1-3/Blood Volume:

Adults blood volume is about 7% of body weight **[29][32].**

The average blood volume in men is about 5.5 liters, and it is approximately 4.5 liter **[52].**

1_4 blood composition

The average human adult has more than 5 liters (6 quarts) of blood in his or her body. Blood carries oxygen and nutrients to living cells and takes away their waste products. It also delivers immune cells to fight infections and contains platelets that can form a plug in a damaged blood vessel to prevent blood loss [**80].**

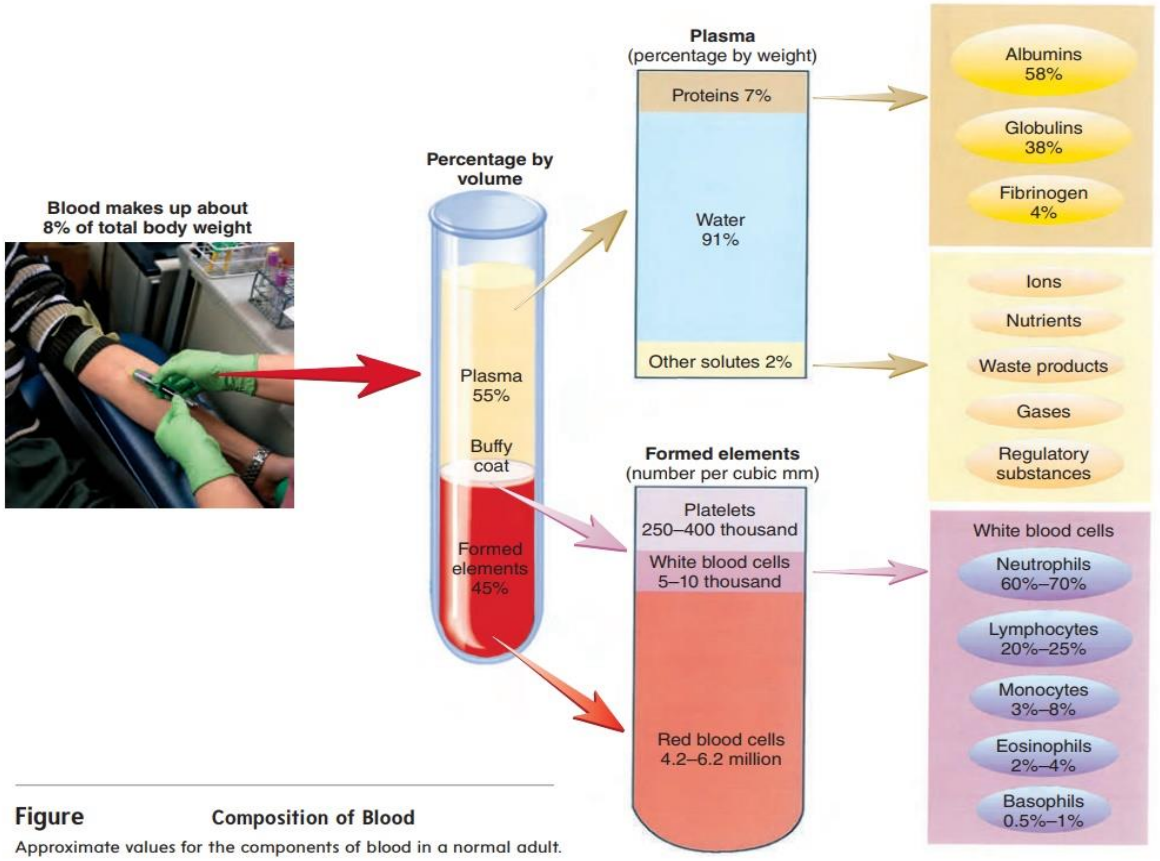

Figure.06: composition of blood **[57].**

1.5- blood figure elements:

1.5.1-Erythrocytes (red blood cells)

Erythrocytes: or red blood cells, are the most numerous of the formed elements. Erythrocytes are tiny biconcave disks, thin in the middle and thicker around the periphery. The shape provides a combination of flexibility for moving through tiny capillaries with a maximum surface area for the diffusion of gases. The primary function of erythrocytes is to transport oxygen and, to a lesser extent, carbon dioxide **[4].**

1.5. 2-Leucocytes (white blood cells)

Leucocytes are colourless blood cells. They are colourless because it is devoid of hemoglobin. They are further classified as granulocytes and agranulocytes. WBCs mainly contribute to immunity and defense mechanism **[68].**

1.5.2.1-Types of white blood cells

A) **Monocytes:** They have a longer lifespan than many white blood cells and help to break down bacteria **[3].**

B) Lymphocytes: They create antibodies to fight against bacteria, viruses, and other potentially harmful invaders **[3].**

C) **Neutrophils:** They kill and digest bacteria and fungi. They are the most numerous types of white blood cell and your first line of defense when infection strikes **[3].**

D) Basophils: These small cells seem to sound an alarm when infectious agents invade your blood. They secrete chemicals, such as histamine, a marker of allergic disease, that help control the body's immune response **[3].**

E) Eosinophils: They attack and kill parasites and cancer cells, and help with allergic responses **[3].**

1.5. 3- Platelets (also called thrombocytes)

Unlike red and white blood cells, platelets are not actually cells but rather small fragments of cells. Platelets help the blood clotting process (or coagulation) by gathering at the site of an injury, sticking to the lining of the injured blood vessel, and forming a platform on which blood coagulation can occur. This results in the formation of a fibrin clot, which covers the wound and prevents blood from leaking out. Fibrin also forms the initial scaffolding upon which new tissue forms, thus promoting healing **[64**].

1.5.2-Plasma

The liquid component of blood is called plasma, a mixture of water, sugar, fat, protein, and salts. The main job of the plasma is to transport blood cells throughout your body along with nutrients, waste products, antibodies, clotting proteins, chemical messengers such as hormones, and proteins that help maintain the body's fluid balance **[66].**

1.6-Blood fonction

Blood has three main functions: transport, protection and regulation.

1.6.1-Transport:

Blood transports the following substances

Gases, namely oxygen (O_2) and carbon dioxide (CO_2), between the lungs and rest of the body Nutrients from the digestive tract and storage sites to the rest of the body Waste products to be detoxified or removed by the liver and kidneys Hormones from the glands in which they are produced to their target cells Heat to the skin so as to help regulate body temperature **[79].**

1.6.2-Acid-base regulation:

To maintain homeostasis, the human body employs many physiological adaptations. One of these is maintaining an acid-base balance. In the absence of pathological states, the pH of the human body ranges between 7.35 to 7.45, with the average at 7.40 **[60].**

To keep blood pH within the optimal range, multiple homeostatic mechanisms regulate processes and molecules which contribute to pH:

1. Chemical acid-base buffer systems (Bicarbonate buffer system)
2. Respiration, and its control by the respiratory center
3. The kidneys **[42].**

1.6.3-Coagulation

Formation of a blood clot to prevent bleeding **[1].**

1.6.4-Hemostasis

Hemostasis is the mechanism that leads to cessation of bleeding from a blood vessel. It is a process that involves multiple interlinked steps. This cascade culminates into the formation of a “plug” that closes up the damaged site of the blood vessel controlling the bleeding. It begins with trauma to the lining of the blood vessel **[24].**

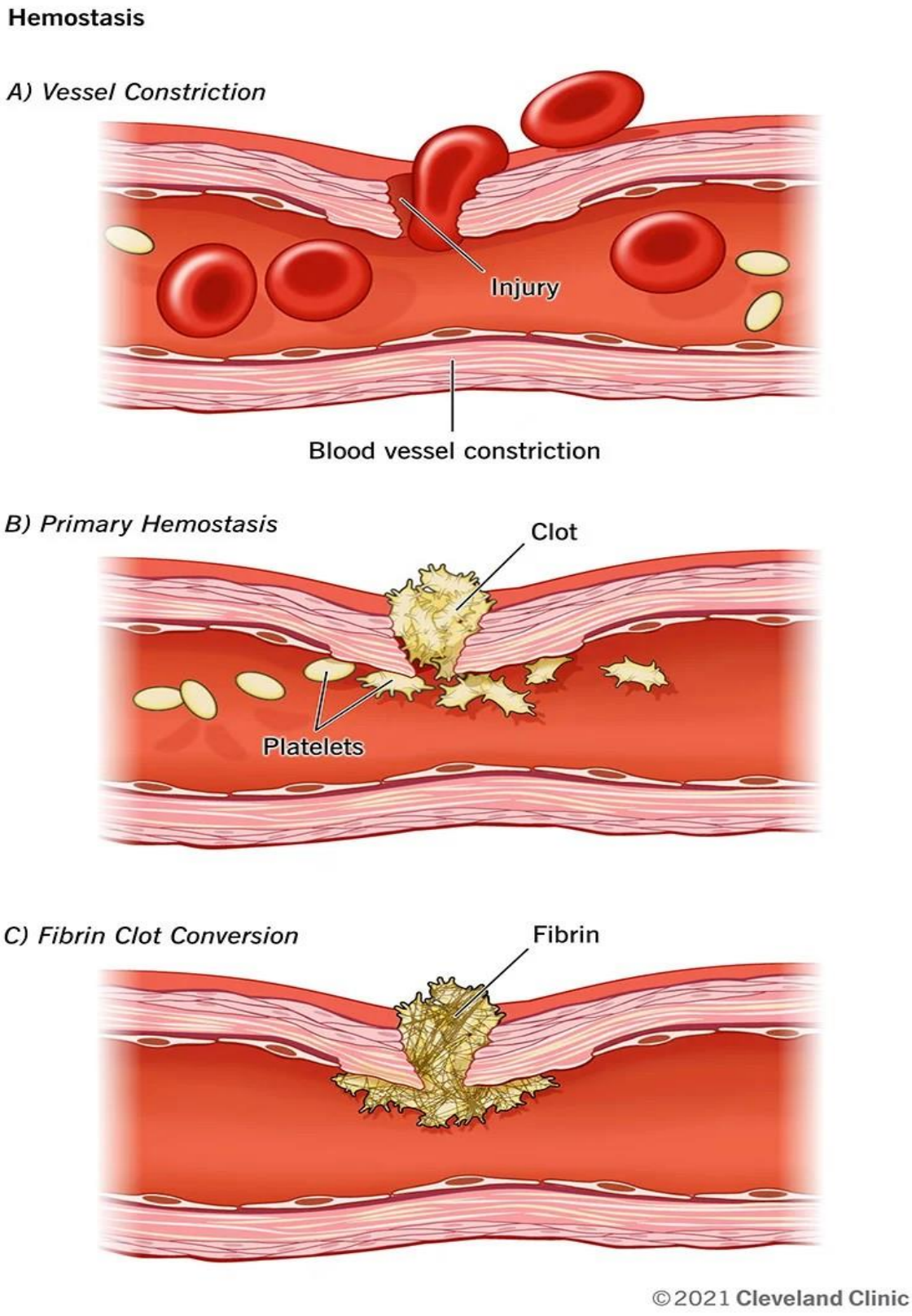

Figure.07: Hemostasis is how your body plays and repair a wound **[67].**

1.5.6-thermoregulation

Maintaining an optimal body temperature, by absorbing and distributing heat throughout the body (from the heart to the surface and vice versa) **[2].**

1.6.6-Protection

This involves solid parts of the blood such as blood platelets and various substances that are dissolved in the blood plasma. If a blood vessel is damaged, these parts of the blood stick together (clot) very quickly and make sure that a scrape, for instance, stops bleeding. This prevents large amounts of blood loss. White blood cells and certain chemical messengers also play an important role in the immune system **[61].**

Experimental part

Materials and methods

1- Materials and methods

Objective

The study aims to evaluate the impact of pollution on human health by comparing the results of medical analyses (hematological and biochemical parameters) such as markers of inflammation, WBC, RBC, and PLT. between El Ma Labiodh Municipality population and Ferkan Municipality, and to identify any health problems resulting from cement pollution.

Administrative agreement

Official permission was taken from the clinics and cement factory before establishing the study and both verbal and written consents were taken.

Study period and setting

We conducted a cross-sectional study that took place from January 25, 2023, to April 17, 2023. The study population included two groups, one of which consisted of 80 individuals affected by cement pollution (from residents of El Ma Labiodh) and the other consisted of 80 residents of the municipality Ferkan exposed to high temperature.

1.1 -Description of the work site

Study area

The wilaya (province) of Tebessa is located in the eastern region of Algeria, with a surface area of around 13,878 square kilometres. It is bordered to the north by the Wilaya of Souk Ahras, to the south by the wilaya of El Oued, to the west by the Wilayas of Oum El Bouaghi and Khenchela, and to the east by the Algerian-Tunisian border **[6].**

1-1-1 The municipality of Ferkan

The municipality of Ferkan consists of two residential agglomerations, Jarish and Madila. It is located in the south of the wilaya at a distance of 170 km. It is bordered to the north by the municipality of El Ogla and the borders of the wilaya of Khenchela, to the east by the municipality of Negerin, to the west by the borders of the wilaya of Biskra, and to the south by the borders of the wilaya of El Oued It has a semi-desert climate. It is an agricultural area, especially desert farming **[81].**

1-1-2- The plain of El Ma Labiodh

El Ma Labiodh is an agricultural plain of 420 km2 located in the South East of

the city of Tebessa, in the North East of Algeria. The eastern limit of the plain approaches Tunisian territory in the region of Kodiat sidi Salah. To the west is the plain of Cheria. The southern limit constituted by the syncline of Bir Sbeikia.

The economy of the region is based on agriculture and mining. It is in fact with a strong pastoral vocation and moreover constituted a route area for sheep herds until the early 1990s. Since that time, the region has experienced very significant industrial activity and water consumption, mainly the Portland cement industry (ERCE), the glass industry (SOVEST) and the rolled tubes industry (ANABIB) **[14].**

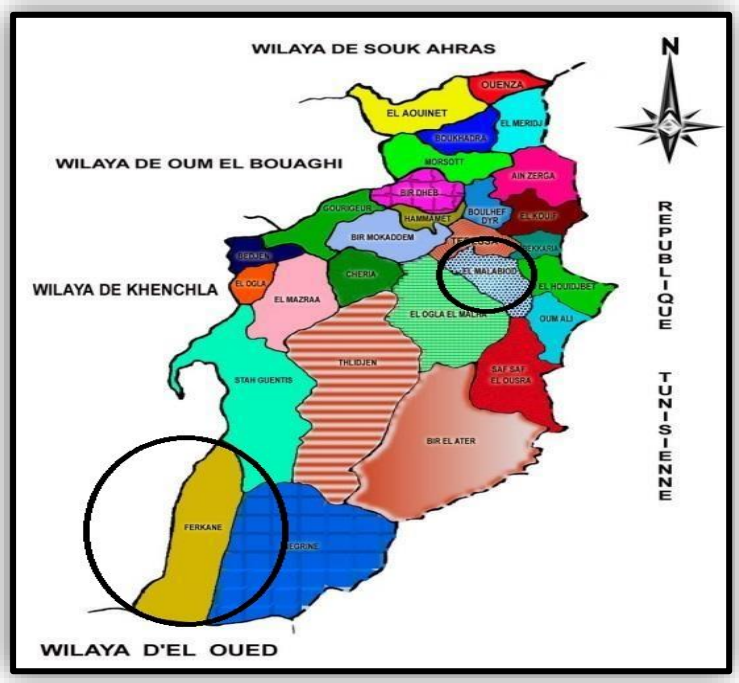

Figure 08: The administrative boundaries of the municipality of Ferkan and the municipality of El Ma Labiodh

1.2-The ERCE Cement Industry

The company was created in November 1993. The head office is located in Tebessa, 680 km south-east of Algiers and 250 km from the city of Annaba in the north. The cement industry is located 26 km south of Tebessa and 35 km from the Algerian Tunisian borders, it is the latest public achievement in the cement sector **[47].**

The cement at a capacity of 1600 tons/day of clinker corresponds to 500000 tons/year. She is endowed of a dry cooking line. It draws its main raw materials from deposits close to the site (limestone: 500m and clay: 10Km) **[82].** The reserves of raw materials allow an exploitation of more than 100 years **[47].**

Figure.09: El Ma Labiodh Cement Industry (personal photo).

Study population

This study included 160 subjects of both sexes and in all age groups, 80 of whom were exposed to the pollutants of the El Ma Labiodh cement plant and 80 of whom were exposed to the temperature.

population exposed of the cement factory:

Are included all adult subjects, children and old people of both sexes who live near the cement factory of El Ma Labiodh (inhabitants of El Ma Labiodh).

We conducted our study at the medical analysis laboratory in El Ma Labiodh municipality clinic, it included individuals exposed to pollution from the cement industry located in El Ma Labiodh, as well as individuals affected by high temperatures in Ferkan.

Population exposed to the temperature:

Are retained the subjects who live outside the city of El Ma Labiodh of both gender (inhabitants of Ferkan).

Material and methods

5- **Equipment and Devices Used in Analytical Laboratories**

Skin-cleansing materials: Alcohol, chlorhexidine, or povidone-iodine swabs or wipes

Nonsterile gloves (sterile gloves if blood cultures are being obtained)

Tourniquet, single-use

Needle system (eg, needle and syringe, or needle and vacuum tube, typically 21-gauge needles for adults; 22- or 23-gauge for neonates, small children, and sometimes older patients)

Blood-collection tubes and blood-culture bottles, as appropriate

Dressing materials (eg, tape, gauze, bandages)

Optional equipment includes

Vein-finder device (eg, infrared vein viewer, ultrasonography device)

1. Topical aesthetic (standard for children): Needle-free lidocaine gas injector, lidocaine-epinephrine-tetracaine mixture, or lidocaine-prilocaine cream [42].

There are a variety of equipment and devices used in analytical laboratories, including:

- Spectrophotometer: Used to measure the absorbance or transmission of light through a sample, often for quantitative analysis.

Figure 10 :: **Spectrophotometer (personal photo)**.

- Chromatography systems: Used to separate and identify components in a sample, including gas chromatography (GC), liquid chromatography (LC), and high-performance liquid chromatography (HPLC).

- NSF automat: Used to identify and quantify the chemical composition of a sample based on its mass-to-charge ratio.

- Microscopes: Used to examine samples at a microscopic level, including light microscopes, electron microscopes, and fluorescence microscopes **[75].**

Figure 11 :Microscope (personal photo).

- pH meters: Used to measure the acidity or alkalinity of a solution **[75].**

Figure 12:pH meter (personal photo)

- Centrifuges: Used to separate components in a sample by spinning it at high speeds.

Figure 13: Centrifuge (personal photo)

Figure 14:Water bath [75]

5-1-How to Do Venous Blood Sampling

a) Step-by-Step Description of Procedure

- Do a preliminary inspection (nonsterile) to identify a suitable vein: Apply a tourniquet, have the patient make a fist, and palpate using your index finger to locate a large-diameter vein that is nonmobile and has good turgor.

- To help distend and locate veins, tap a potential site with your fingertips. It may help to allow the arm to hang down, increasing venous pressure. Use a vein-finder device if a suitable vein is not readily seen or palpated.

- After identifying a suitable cannulation site, remove the tourniquet.

- Apply anesthetic if it is being used and allow adequate time for it to take effect (eg, 1 to 2 minutes for gas injector, 3 minutes for topical).

- Cleanse the skin site with an antiseptic solution, beginning at the needle-insertion site and making several outwardly expanding circles.

- Wait for the antiseptic solution to dry completely. If applying povidone-iodine, wipe it off with alcohol and allow the alcohol to dry.

- If blood is being obtained for blood cultures, vigorously cleanse the site with alcohol for 30 seconds, allow the alcohol to dry, and then swab in outwardly expanding, overlapping circles using chlorhexidine or povidone-iodine. Wait for the antiseptic effect to occur (1 minute for chlorhexidine or 1.5 to 2 minutes for iodine). Wipe off povidone-iodine with alcohol and allow the alcohol to dry. For children, swab the site 3 times using only alcohol. After this point, do not touch the skin site with any nonsterile item.

Figure.15: sampling technique **(personal photo)**

b) Obtain the blood sample

- Try to access the vein efficiently and collect the blood sample within 30seconds after tourniquet placement. Do not leave the tourniquet on for > 1 minute.

- Reapply the tourniquet proximal to the selected insertion site. Do not have patients make a fist or let their arm hang down during the blood sampling, because these maneuvers may cause various erroneous laboratory values (eg, increased potassium, lactate, phosphate).

- Palpate with your gloved finger to locate the middle of the target vein.

- Apply gentle traction to the vein distally using the thumb of your non-dominant hand to prevent the vein from moving. Traction may not be necessary for larger veins of the forearm or antecubital fossa.

- Tell the patient that the needlestick is about to happen.

- Insert the needle proximally (ie, in the direction of venous blood flow), with the bevel facing up, along the midline of the vein at a shallow angle (about 10 to 30 degrees) to the skin.

- Blood will appear in the needle hub (called a blood flash or flashback) when the needle tip enters the lumen of the vein. Stop advancing the needle, lower the needle to

better align it with the vein, and advance it into the vein an additional 1 to 4 mm, to ensure that it stays in position during blood collection.

- If no flash appears in the hub after 1 to 2 cm of insertion, withdraw the needle slowly. If the needle had initially passed completely through the vein, a flash may now appear as you withdraw the needle tip back into the lumen. If a flash still does not appear, withdraw the needle almost to the skin surface, change direction, and try again to advance the needle into the vein.

If rapid local swelling occurs, blood is extravasating. Terminate the procedure: Remove the tourniquet and the needle and apply pressure to the puncture site with a gauze pad (a minute or 2 is usually adequate unless the patient has a coagulopathy) **[46].**

- Keep the needle motionless.

- Begin to withdraw the blood sample and, when blood begins to flow, remove the tourniquet.

- When using vacuum tubes, push each tube fully into the tube holder, and use care to avoid dislodging the needle from the vein. Fill multiple collection tubes in the proper sequence. After removing a tube from the holder, gently invert the tube 6 to 8 times.

- the contents; do not shake the tubes.

- When using a syringe, pull back on the plunger gently to avoid damaging the blood cells or collapsing the vein.

- When blood collection is complete, gently hold a folded gauze square at the venepuncture site with your nondominant hand, and in one motion remove the needle and immediately apply pressure to the site with the gauze. Remove the tourniquet if you did not do so earlier.

- Have the patient or an assistant continue to apply pressure to the site.

- If you used a syringe to collect the blood, now transfer samples to collection tubes and bottles either insert the needle directly into the tops of the vacuum tubes or remove the needle and attach a vacuum tube holder to the syringe. Do not inject blood into vacuum collection tubes; allow the vacuum to draw the blood into the tube. After the blood

has been added to a tube, gently invert the tube 6 to 8 times to mix the contents; do not shake the tubes.

Deploy a safety cover over the exposed needle. Deposit used blood-collection devices (with needles) into a sharp's container. Do not recap non-safety needles before disposal unless a sharps container is not immediately available **[46].**

6- The biochemical analyses conducted at Ferkan and EL Ma Labiodh clinics included

A) White blood cells **(WBC)**

B) Lymphocytes **(LYM**)

C) Red blood cells **(RBC)**

D) Hematocrit **(PCV)**

E) Platelet Count **(PLT)**

F) Glycemia

G) Urea

H) Creatinine

I) Erythrocyte Sedimentation rate **(ESR)**

J) Triglyceride **(TG)**

7- The way to prepare the analyses

7-1-). Biochemical examinations

-a) The manual way to prepare GLYCEMIA

- Take 3 dry tubes.
- Using a micropipette, add 1000µl of glucose reagent to each tube.

- Add 10µl of the standard glucose solution to tube 2, 10µl of serum sample to tube 3, and leave tube 1 as a blank to adjust the zero of the spectrophotometers.

- Incubate all 3 tubes in an oven for 5 minutes.

- Using a spectrophotometer, read the absorbance (DO) of all 3 tubes at a wavelength of 505nm **[74].**

- Calculate the glucose concentration (C) of the serum sample using the following formula: C=DO of the sample / DO of the standard, where n is the concentration of the standard glucose solution.

- Express the result in g/l.

- Compare the result with the normal range of blood glucose levels, which is typically 0.7-1.20 g/l.b)

B) The manual way to prepare Blood urea

The urea is dosed according to the following reaction

$$\text{Urea} + H_2O \longrightarrow 2NH_3 + CO_2$$

- We take 3 dry tubes
- Put 1000µl of Reagent 1 (R1) in each tube
- Put 10µl of standard solution in tube 2, 10µl of serum in tube 3 and tube 1 is a blank
- Put the three tubes in the oven for 5 min
- 1000µl of Reagent 2 (R2) is added to each tube
- Then we leave the tubes in the oven for 5min
- The OD is read with a spectrophotometer at a wavelength
- 590 nm
- The calculation is as follows: C = OD of sample/DO of standard 0.5 g/l
- Normal value: 0.1-0.5 g/l

c) The manual method for preparing creatinine is as follows

- Take a clean test tube.
- Add 100 µl of serum or plasma to the test tube using a micropipette.
- Add 1 ml of alkaline picrate reagent to the test tube and mix well.
- Incubate the test tube in a boiling water bath for 3 minutes.
- After incubation, remove the test tube and cool it to room temperature.
- Measure the absorbance of the sample at a wavelength of 500 nm using a spectrophotometer.
- Calculate the concentration of creatinine using a standard curve and express it as mg/dL or µmol/L.

Note: The standard curve is prepared by using a series of known concentrations of creatinine and measuring their absorbance at 500 nm **[74].**

d) The manual method for preparing Triglyceride is as follows

- Take a clean test tube.
- Add 20 µl of serum or plasma to the test tube using a micropipette.
- Add 1 ml of reagent (Triglyceride GPO-PAP) to the test tube and mix well.
- Incubate the test tube in a water bath at 37°C for 5 minutes.
- After incubation, measure the absorbance of the sample at a wavelength of 500 nm using a spectrophotometer.
- Calculate the concentration of triglycerides using a standard curve and express it as mg/dL or mmol/L.
- Note: The standard curve is prepared by using a series of known concentrations of triglycerides and measuring their absorbance at 500 nm. The Triglyceride GPO-PAP reagent contains glycerol phosphate oxidase and peroxidase, which react with triglycerides to produce a color that can be measured by spectrophotometry **[74].**

e) The manual method for preparing Erythrocyte Sedimentation Rate (ESR) is as follow

- Take 2 ml of venous blood from the patient and transfer it to a clean, dry, and sterile tube.

Leave the tube undisturbed for 1 hour to allow the red blood cells in the sample to settle **[74].**

- After 1 hour, measure the height of the clear serum (in millimetres) present above the settled red blood cells.

- Record the height of the serum as the sedimentation rate (Vs) in millimetres per hour.

Note: The sedimentation rate is a non-specific marker of inflammation in the body and can be affected by various factors such as age, gender, anemia, and pregnancy. Therefore, it is important to interpret the sedimentation rate in conjunction with other clinical and laboratory findings **[74].**

- SR 1st hour < 12 mm

- SR 2nd hour < 18 mm

7.2- Hematological analyses of blood

Hematological analyses are performed on blood to enable the diagnosis or monitoring of certain diseases. Hematology includes the analysis of blood cells but also elements dissolved in the plasma such as coagulation factors or antibodies.

A) clinical routine testing blood analysis CBC-6000

This instrument is controlled by an inlaid controller which has powerful function and accuracy. It owns advantages like high accuracy, high speed, excellent repeat function, super-automatic and complete function. Compared with similar products, the rate of performance and the price are more competitive. The instrument counts by electrical impedance method. It will use three kinds of reagents on it. It can proceed auto-diluents on

it. It can do a 3-part differential on WBC, and test 22 parameters like WBC, RBC, HGB, PLT, MCV, etc. in high accuracy **[41].**

The software has a powerful function and an excellent save function. It can save all the 35000 tested parameters and 3 histograms. It is very simple to operate. The menu is similar to WINDOWS. The software has a powerful function to manage the hardware. It can test and find almost all the faults existing in the instrument. And it is very convenient for users to operate. The instrument can be connected to the printer outside and print a very nice test report **[41].**

Detection principles of WBC, RBC, PLT.

The instrument method accurately counts and sizes cells by detecting and measuring changes in electrical resistance when a particle (such as a cell) passes through a gem aperture sensor.

a) Sample is diluted in a conductive liquid, the blood cell is a bad conductor, but the diluent is well conductor, there is a difference between them.

b) As each cell goes through the gem aperture sensor, current goes through the two electrodes nearby.

c) When a cell goes through the aperture, the resistance is increase as cell volume increase.

d) Treat by magnifying circuit, the voltage signal is amplificatory and background noise is removed, then can receive the signal to analysis.

e) WBC is analysed by the test counter and detects the circuit, and RBC and PLT are analysed by another test counter and detect the circuit. The MPU analyses and calculates the cells, then gives the histograms.

f) The count of PLT adopts the advanced liquid, electron, and soft system, it can settle the repetitive count of the cells. If RBC enter the analysis area, they will have similar pulses with PLT, which may confuse repetitive count **[40]**.

Figure 16: Clinical laboratory Fully automatic Hematology Analyzer blood test machine CBC-600 [40].

Items	Abbreviation	Units
White blood cell	WBC	10^3/uL
Lymphocyte	LYM#	10^3/uL
Mid-Cell	MID#	10^3/uL
Granulocyte Percent	GRAN#	10^3/uL
Lymphocyte Percent	LYM%	%
Mid-Cell Percent	MID%	%
Granulocyte percent	GRAN%	%
Red blood	RBC	10^6/uL
Hemoglobin concentration	HGB	g/dL
Hematocrit	HCT	%
Mean cell volume	MCV	fL
Mean cell hemoglobin	MCH	pg
Mean cell hemoglobin concentration	MCHC	g/dL
Red Blood Cell Distribution Width-Standard Deviation	RDW-SD	fL
Red Blood Cell Distribution Width-Coefficient of Variation	RDW-CV	%
Platelet	PLT	10^3/uL
Mean Platelet Volume	MPV	fL
Platelet Distribution Width	PDW	%
Platelet crit	PCT	%
Plateletcrit-large Cell Ratio	P-LCR	%
White BLood Cell Histogram	WBC Histogram	
Red Blood Cell Histogram	RBC Histogram	
Platelet Histogram	PLT Histogram	

Figure 17: Displaying the results on a device clinical routine testing blood analysis CBC-6000.

Table02 : Normal values of measured parameters

RBC (10^12/L)	3.79-5.78
WBC (10^3 /L)	5-1
LYM (10 3/L)	1.35 – 3.50
PLT (10^3 /L)	156 -342
HCT (٪)	34-53.9
CREA (mg/L)	7-14
UREA(g/L)	0.15-0.45
ESR mm	SR 1st hour < 12 mm
	SR 2nd hour < 18 mm
TG (X g/l)	
GLY	0.7-1.10

8 - Statistical analysis

Statistical analysis was performed by using Minitab (designed for statistical analysis) Version 18.

Data were presented as mean and standard deviation (mean ± SD). Unpaired Student's 't' test was done to compare between the groups. p value of < 0.05 was taken as level of significance.

Results and discussion

1.Results

Table 3 : Representing the division of 80 people in EL Ma Labiodh, classified by age and gender

El Ma Labiodh				
l age	1 to 15	15 to 30	30 to 60	60 to 90
Total	20	20	20	20
Female	10	10	10	10
Male	10	10	10	10

Table 4 :Representing the division of 80 people in Ferkan, classified by age and gender

FERKAN				
l age	1 to 15	15 to 30	30 to 60	60 to 90
Total	20	20	20	20
Female	10	10	10	10
Male	10	10	10	10

Table 5 :White blood cells number of EL Ma Labiodh and Ferkan habitants (X103) / L

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	11.88± 0.83	8.63± 1.51	8.17± 2.49	11.21± 1.13
Female FERKAN	6.21±1.39	6.61±2.25	7.05±1.37	6.09± 0.74
Male EL Ma Labiodh	11.67±0.66	9.46 ± 1.66	11.25±1.77	12.93± 2.47
Male FERKAN	4.55 ±1.06	5.61±1.24	6.31 ± 2.47	6.97 ±2.06

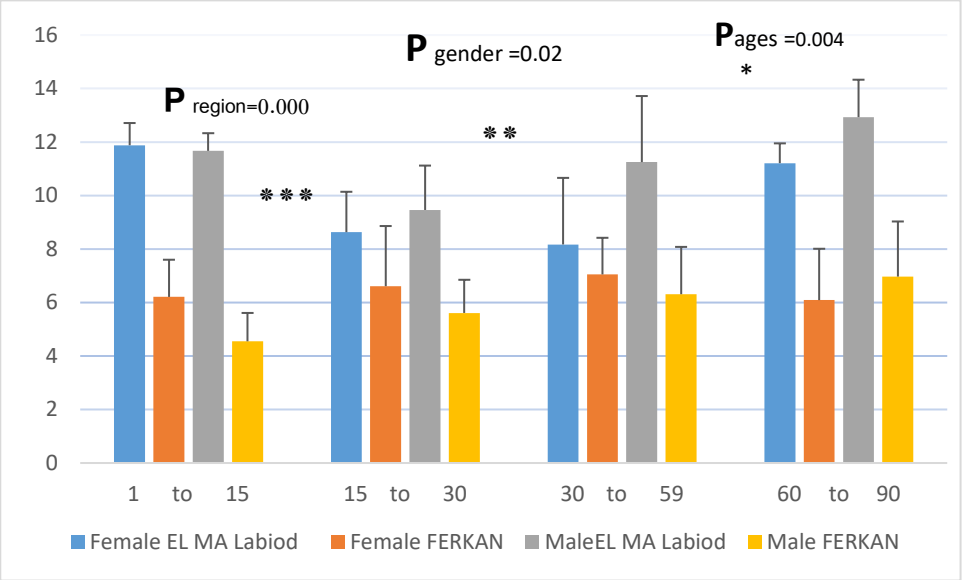

Figure 18: Representation of White blood cells number of El Ma Labiodh and Ferkan habitants

Normal white blood cell counts 05-10

The figure represents the variation in the number of white blood cells in females and males in each of the EL Ma Labiodh and FERKAN regions, where we note: the percentage of white blood cells is high for females and males in all groups in the EL Ma Labiodh region, ($p \leq 0.001$) compared to Ferkan region, which is within Its normal value is (5_10g/L).

Table 06 :Lymphocytes number of El Ma Labiodh and FERKAN habitants (X 103 / L)

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	2.83 ±0.55	2.48 ±0.98	3.20 ±1.65	2.82 ±1.27
Female FERKAN	2.03 ±1.30	1.99 ±1.02	1.26 ±0.43	1.94±1.15
Male EL Ma Labiodh	3.40 ±1.13	2.35 ±1.02	2.48 ±1.2	2.21 ±0.55
Male FERKAN	2.21 ±1.34	2.72 ±1.04	0.83 ±0.35	2.22± 1.11

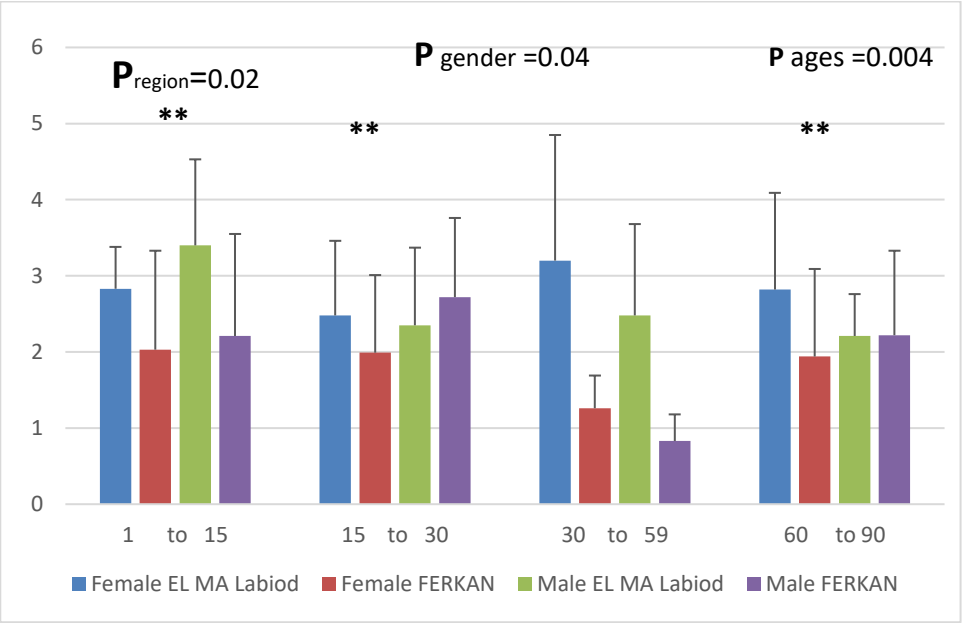

Figure 19: Representation of Lymphocyte cells number of El Ma Labiodh and Ferkan habitants.

Normal Lymphocyte cells count (1.35 – 3.50)

The figure represents the variation in the number of lymphocytes for both gender at different ages in both of EL Ma Labiodh and Ferkan regions.

We note that the number of lymphocytes is high in females and males in all groups ($p \leq 0.01$) compared to Ferkan, which is within the normal value (1.35 _3.50/l).

Table07: Red blood cells number of El Ma Labiodh and Ferkan habitants (X 1012/L).

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL MA Labiodh	3.73±0.84	4.47 ±0.65	3.67 ±0.73	3.59 ±0.59
Female FERKAN	4.27 ±0.54	4.36 ±0.39	4.45 ±0.66	4.37 ±0.72
Male EL MA Labiodh	2.60 ±0.90	5.75±1.08	1.88 ±1.23	2.98±0.76
Male FERKAN	5.77 ±0.77	4.83 ±0.38	4.18 ±0.02	5.30 ±0.53

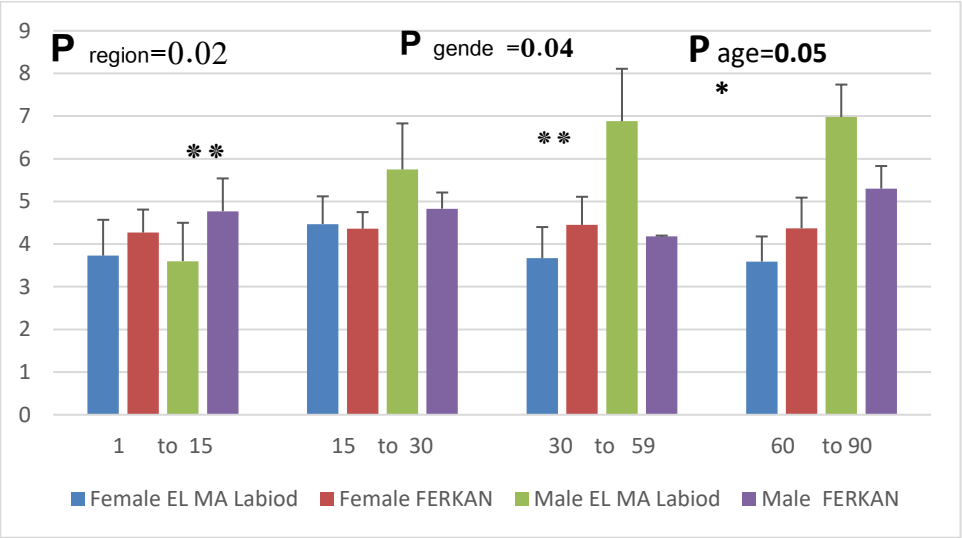

Figure 20: Representation of Red blood cells number of El Ma Labiodh and Ferkan habitants.

Normal Red blood cells count (3.79-5.78)

The figure represents the variation in the number of red blood cells for both gender at different ages in both of El Ma Labiodh and Ferkan regions.

We notice an increase in the number of red blood cells for both sexes at different ages, and it is higher in each of the third category (30 to 59) and the fourth (59 to 90) in El Ma Labiodh area, ($p \leq 0.05$) compared to Ferkan, which is within the normal value (3.79-5.78/L).

Table 8: Hematocrit (HCT %) number of El Ma Labiodh and Ferkan habitants.

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	36.80 ±5.10	33.05± 3.41	33.05 ±5.72	33.84 ±0.47
Female FERKAN	30.35 ±4.97	30.20± 3.60	30.50 ±7.57	30.37 ±4.82
Male EL Ma Labiodh	35.71 ±4.28	36.71 ±5.72	36.46 ±4.58	36.30 ±5.75
Male FERKAN	29.16 ±2.97	30.7 ± 5.52	28.72 ±5.47	28.11 ±5.16

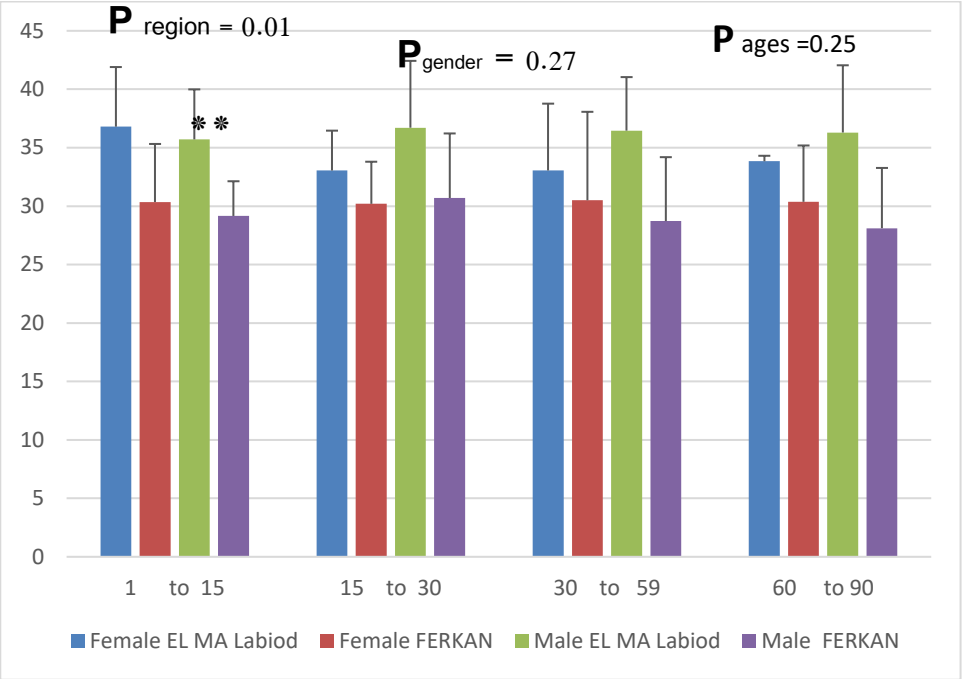

Figure 21: Representation of HT % Hematocrit number of El Ma Labiodh and Ferkan habitants.

Normal Hematocrit ratio HT % (34-53.9)

The figure represents the variation in the percentage of HT for both gender at different ages in each of EL Ma Labiodh and Ferkan regions.

Where it is high in EL Ma Labiodh area for both gender in all groups, ($p \leq 0.01$) compared to Ferkan area, which is within the normal value (34-53.9%).

Table09: PLT number of El Ma Labiodh and Ferkan habitants (10^3 /L).

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	238.2± 55.77	246.7±66.32	246.6±66.32	292.45±70.6
Female FERKAN	259.3±102.95	236.1±103	207.3±48.89	251.3±68.13
Male EL Ma Labiodh	397.7±80. 30	279.7±84.39	410.2±70.47	378.5±55.12
Male FERKAN	254.9±93.03	232.2±35.96	261.9±83.48	263.1±79.8

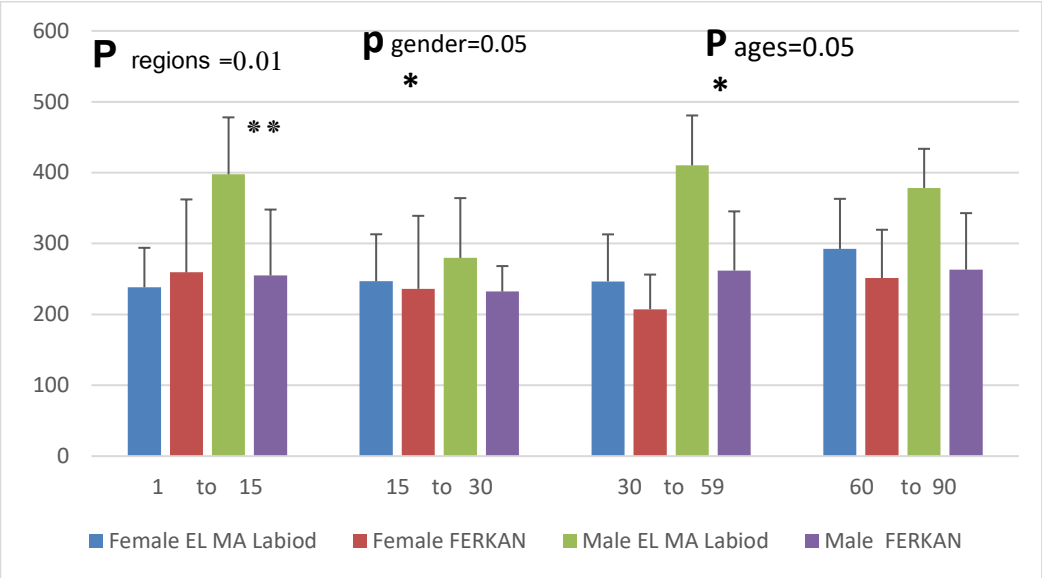

Figure 22: Representation of PLT number of EL Ma Labiodh and FERKAN habitants

Normal PLT number (156 –342)

The figure represents the variation in the number of PLT for both females and males in all categories for both of EL Ma Labiodh and Ferkan regions.

We observe an increase in the number of PLT in males, in all categories except the second category ($p \leq 0.01$)

Comparison of Ferkan area where the PLT number is within the normal value(156-342×10^3/L).

Table 10: Glycemia number of El-Ma Labiod and Ferkan habitants (g/l)

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	0.98±0.17	0.84±0.10	1.00±0.43	1.09±0.19
Female FERKAN	0.88±0.16	0.80±0.04	0.97±0.33	0.69±0.45
Male EL Ma Labiodh	1.08±0.61	1.07±0.41	1.15±0.68	1.75±0.52
Male FERKAN	0.87±0.09	0.81±0.08	1.04±0.23	1.00±0.16

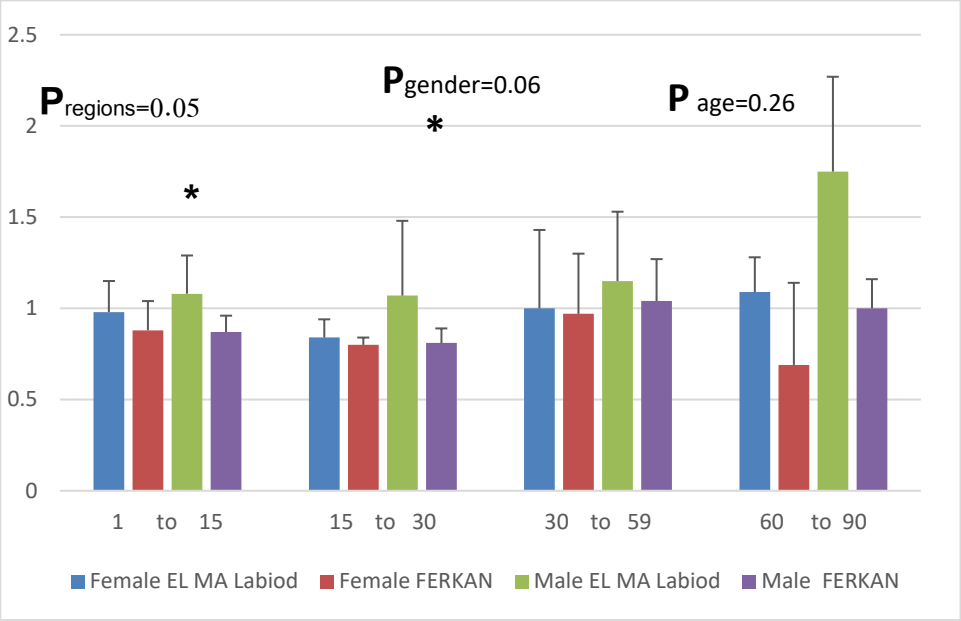

Figure 23: Representation of glycemia value of EL Ma Labiodh and FERKAN habitants.

Normal glycaemia value (0.7-1.10)

The figure represents the variation in glycemia value for both gender at different ages in EL Ma Labiodh and Ferkan regions.

We notice an increase in the percentage of glycemia among males in the fourth category (59 out of 90), while it is moderate in the rest of the groups for both gender in the EL Ma Labiodh area ($p \leq 0.05$) compared to the Ferkan area, where the blood glycemia percentage is moderate for both gender at different ages within the normal value (0.7-1.10 g / l).

Table 11: Blood urea number of EL Ma Labiodh and Ferkan habitants(g/l)

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	0.37 ±0.09	0.30 ±0.13	0.32 ±0.09	0.46±0 .10
Female FERKAN	0.23 ±0.13	0.25±0.08	0.25±0.08	0.26 ±0.15
Male EL Ma Labiodh	0.34 ±0.08	0.36 ±0.09	0.37 ±0.11	0.50 ±0.11
Male FERKAN	0.24 ±0.11	0.29 ±0.14	0.35 ±0.14	0.25 ±0.08

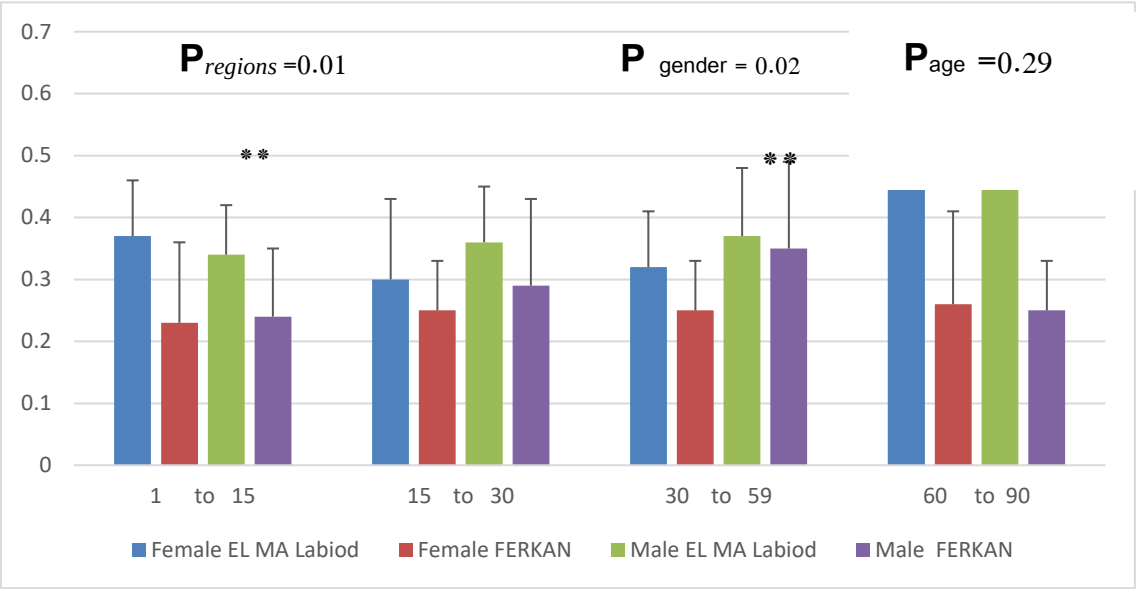

Figure 24: Representation of Blood urea number of EL Ma Labiodh and Ferkan habitants

Normal Blood urea value (0.15-0.45)

This figure represents the variation in urea ratio for both gender at different ages in the regions of EL Ma Labiodh and Ferkan.

We notice an increase in the percentage of urea in both females and males in the fourth group (59 to 90), while it is moderate for the rest of the groups in the EL Ma Labiodh region, compared to the normal ratio (0.15-0.45 g/L), while it is high in all groups, ($p<0.01$) compared to Ferkan area, which is within the normal value (0.15-0.45 g/l).

Table 10 :Creatinine (mg/L) of EL Ma Labiodh and Ferkan habitants

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	8.89 ±2.55	9.83±3.01	8.90 ±1.04	10.59 ±1.68
Female FERKAN	7.02 ±1.47	7.67±1.02	7.22 ±2.32	7.01±1.44
Male EL Ma Labiodh	8.91 ±2.25	9.89±3.42	10.98 ±2.69	11.00±3.17
Male FERKAN	7.67 ±1.50	8.07±1.41	8.89 ±1.36	8.90±1.02

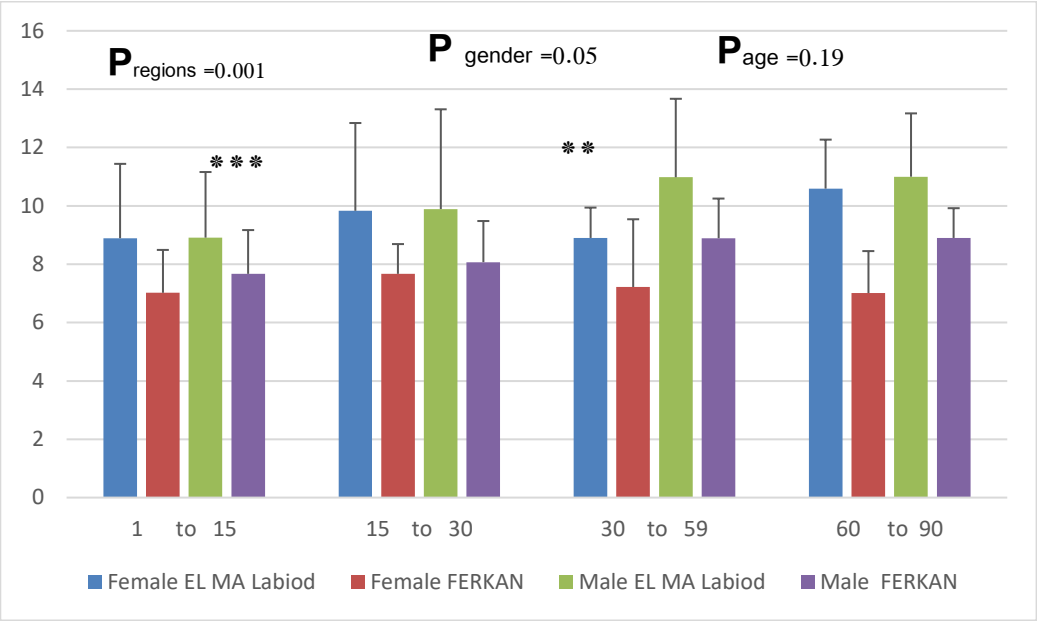

Figure 25: Representation of Creatinine of EL Ma Labiodh and Ferkan habitants Normal Creatinine number (7-14).

The figure represents the variation in creatinine for both gender at different ages in both EL Ma Labiodh and FERKAN. We notice that it is moderate in both gender and in all groups in EL Ma Labiodh region compared to the normal value (7-14 mg/L)

while we notice a higher ($p \leq 0.001$) compared to Ferkan region, which is within the normal limits (7-14 mg/L).

Table 11:triglyceride (TG g/l) of EL Ma Labiodh habitants and Ferkan.

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	1.15 ±0.46	1.28 ±0.38	1.80 ±0.63	1.59 ±0.55
Female FERKAN	0.85 ±0.32	0.89±0.39	0.80 ±0.13	0.65 ±0.23
Male EL Ma Labiodh	1.79 ±0.58	1.50 ±0.60	1.61 ±0.64	2.44 ±0.57
Male FERKAN	0.97 ±0.35	0.92±0.43	1.15 ±0.36	1.07 ±0.40

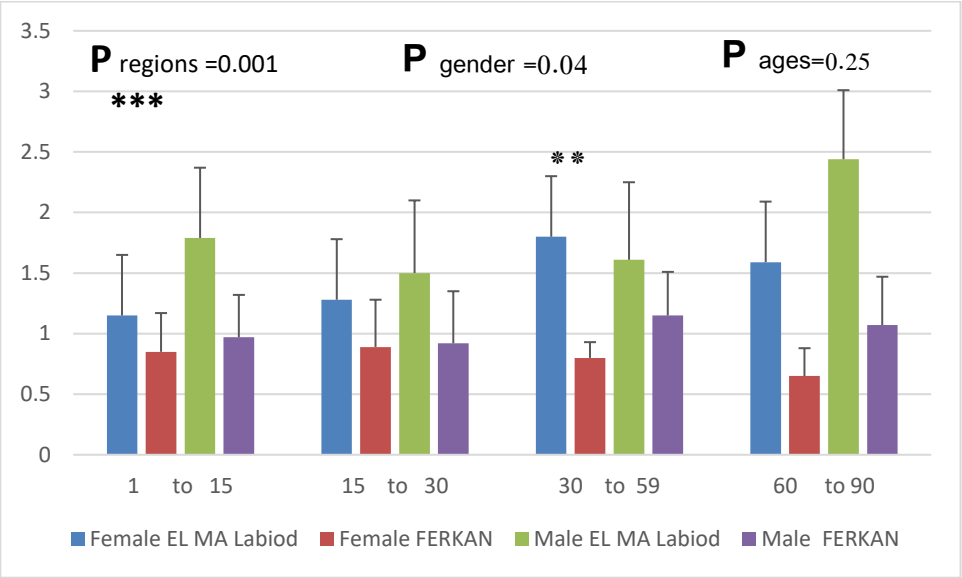

Figure 26: Representation of triglyceride (TG g/l) of EL Ma Labiodh and Ferkan habitants

Normal triglyceride value (0.5-1.5)

The figure represents the variation in triglycerides for both gender at different ages in the regions of El Ma Labiodh and Ferkan.

We note that the value of triglycerides is high in both gender at different ages in the cataract region ($p \leq 0.001$) compared to the Ferkan region, in which the triglycerides ratio in the natural range is (0.50-1.50g/L).

Table 12 :velocity of blood sedimentation VS 1ST HOUR of EL Ma Labiodh and Ferkan habitants

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	10.8±4.07	15.23 ±5.00	9.12 ±4.95	14.5 ±6.23
Female FERKAN	4.9±1.23	5.28 ±1.67	6.34 ±1.39	9..92±2.30
Male EL Ma Labiodh	15.3±5.88	18.21 ±1.49	14.56 ±5.55	17.2 ±8.56
Male FERKAN	6.0±1.54	7.21 ±2.13	7.39 ±2.35	10.23 ±2.38

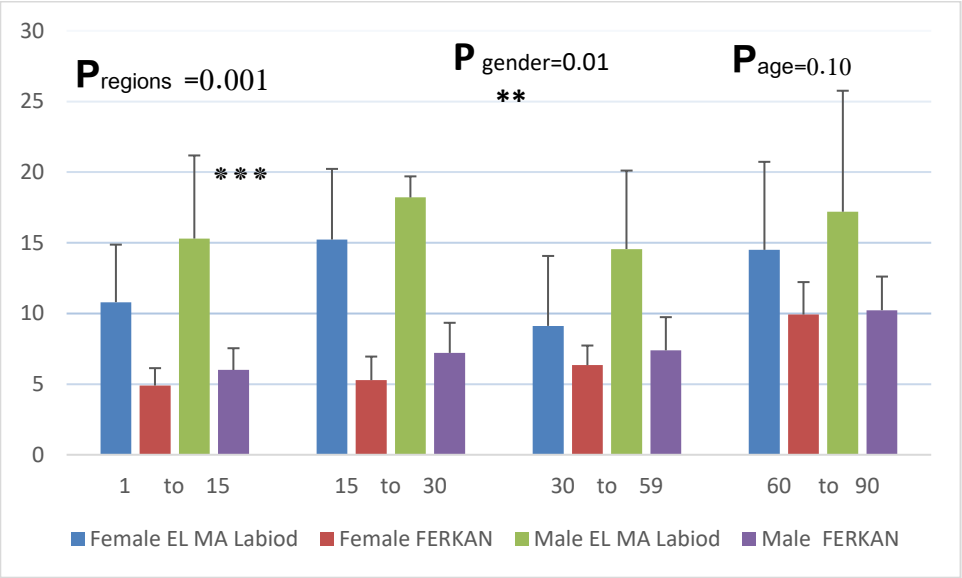

Figure 27: Representation of velocity of blood sedimentation 1ST HOUR of EL Ma Labiodh and Ferkan habitants

Normal value of Vs 1st hour < 12 mm

The figure represents the variation in Vs of deposition within two hours of time, for both gender at different ages in both the regions of EL Ma Labiodh and Ferkan.

Where we notice in the first hour

High deposition speed of both gender at different ages in EL Ma Labiodh region ($p \leq 0.001$).

Compared to Ferkan area, which is within its normal value (Vs < 12).

Table 13 :velocity of blood sedimentation 2ndHOUR of EL Ma Labiodh and Ferkan habitants

	1 to 15	15 to 30	30 to 59	60 to 90
Female EL Ma Labiodh	20.34±6.7	29.65 ±6.78	32.43 ±6.23	37.8 ±6.23
Female FERKAN	17.34± 4.23	17.78±5.67	13.41 ±5.36	18.34±3.89
Male EL Ma Labiodh	20.23±5.88	22.34 ±5.90	31.78 ±5.87	40.5 ±8.56
Male FERKAN	13.34±4.30	15.35 ±5.67	13.11 ±2.93	18.23 ±4.23

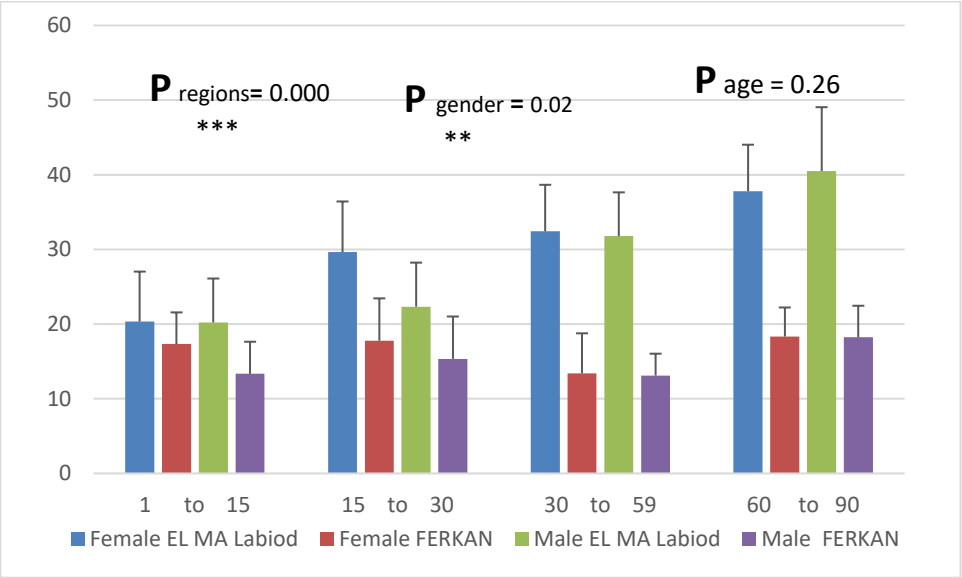

Figure 28: Representation of velocity of blood sedimentation VS 2nd HOUR of EL Ma Labiodh and Ferkan habitants

Normal value of Vs 2nd hour < 18 mm

In the second hour:

We notice an increase in the sedimentation rate for both gender at different ages, as it is very high, especially in the third (30 to 59) and fourth (59 to 90) categories for both gender in EL Ma Labiodh area($P \leq 0.001$) compared to the FERKAN area, which is within its normal value (Vs <18).

2. Discussion

The major pollution problems come from cement factories because of dust and particulate matter emitted at various steps of cement production (Ogunbileje et *al*., 2010).

Our study made it possible to specify the values of 5 hematological parameters; (leukocytes, erythrocytes and platelets, lymphocytes, hematocrit) and a parameter considered as an early marker of inflammation in two different populations (sedimentation rate) and biochemical parameters (urea, creatinine, glycemia, triglycerides); one consisted of 80 individuals exposed to cement pollutants (EL Ma Labiodh), and the other consisted of 80 individuals exposed to temperature (Ferkan).

The distribution of these two populations allows us to highlight some observations, according to the different statistical tools used:

The comparison of the variance of the different variables in the exposed and control individuals, show significant differences for some parameters, so the study of the effect of the health status on the variation of the parameters gives important results.

In this study, white blood cells count was higher in subjects exposed to cement than that of controls and there was positive correlation between the WBC count with the duration of exposure to cement. This result is similar to those in other studies.

It was observed in the study that there was an increase in white blood cell count regardless of the period of exposure. High white cell count represents a primary disorder of leukocyte production or may reflect a secondary response to some disease process or toxins. White cell count is often seen as a biomedical marker for inflammatory response [**56].** Changes in the number of circulating leukocytes can represent a primary disorder of leukocyte production or may reflect a secondary response to some disease process or toxin **[11].**

The increase in the number of white blood cells, may indicate an activation of the system immune system in response to infections, inflammatory syndromes, hematological diseases, allergic and dermatological diseases **[70].**

The significative difference observed in the number of red blood cells shows an increase in number of RBCs in exposed individuals compared to controls that is due to exposure to cement manufacturing dust.

The red blood cell count shows a positive association between the number of the latter and health status. This result is expressed by the activity of cells for the production of RBCs to increase the number of HB molecules to facilitate the adhesion of O_2 molecules, which

facilitates respiratory phenomena **[31].**

We found also that the mean platelet count was significantly higher among exposed groups compared to non-exposed controls.

Higher platelet count observed among subjects occupational exposed to cement may be associated with inflammation. High platelet count has been associated with infections. Platelet count can also potentially increase when a relatively large amount of body tissue is damaged either by exposure to toxins, following surgery or after an accident. This is often part of the body's natural defense mechanism to ensure adequate clot formation and prevent of life-threatening hemorrhage **[44].**

A raised Platelet count may result in increased risk of cardiovascular disease in cement dust exposed workers **[63].** Previous studies in different countries have shown changes in the platelet count in cement factory workers **[69].**

The lymphocytes number was increased significantly in the exposed groups than this of the unexposed.

A study showed that neutrophils, eosinophils and lymphocyte count among hematological indices were significantly increased in exposed individuals compared with control group. Patil and his team thus posit that high level of dust exposure has deleterious effects on blood and tissues due to high oxidative stress **[22].**

Lymphocytes increasing in this study is well evident to be an immune response to the inhaled toxins present in the quarry dust also supported by another study **[5].**

It is reported that quarry dust induces inflammatory mediated DNA damage that causes lymphocytosis **[37].**

Therefore, chronic exposure to quarry dust induces inflammatory response that progress into fibrosis. If the particulate matter inhaled escapes the reticuloendothelial system, it gets phagocytized by the alveolar macrophages triggers the release inflammatory agents like cytokines **[71].**

And also, IL6 and Granulocyte Macrophage Colony Stimulating factor (GMCSF) as a response-to-inhaled-pollutants **[71].**

The packed cell volume (PCV) of the exposed subjects was significantly higher than those of unexposed, this due to a probable cancer risk of lung and renal. The association with lung cancer was largely attributable to cement dust. The association with lung cancer was not affected with the interval from examination to diagnosis, also his may indicate dehydration, which is the main cause of high hematocrit levels, as this may indicate true erythrocytosis, or heart disease congenital, or lung disease.

Several studies have shown a relationship between the hematocrit and incident cardiovascular events in patients who have had an MI **[12].** in those with PAD **[38].** and in asymptomatic individuals **[54].**

However, results of some studies have not shown a significant relationship between hematocrit and CHD risk **[73].** In fact, while most studies of different patient populations do show an association between increased hematocrit and increased risk of CHD, the observed risk ratios are generally low, and, therefore, the clinical usefulness of hematocrit alone is unclear.

A meta-analysis of 19 prospective studies of hematocrit and CHD risk showed a pooled odds ratio of 1.16 (95% CI, 1.05–1.29) in disease-free subjects, and a risk ratio of 1.81 (95% CI, 1.19–2.76) in patients with vascular disease **[53].**

. The same meta-analysis also dealt with the value of viscosity and the ESR for CHD risk prediction. The investigators reported a risk ratio of 1.57 (95% CI, 1.34–1.85) for the top tertial of plasma viscosity in population-based studies, and a risk ratio of 2.6 (95% CI, 1.64–4.12) for patients with vascular disease **[53].**

.

Results of a more recent study show that the hematocrit-to-blood viscosity (Hct-BV) ratio had significant negative correlation with the frequency of hospital admission and that a lower Hct-BV ratio was associated with a greater likelihood of cardiac death in CHD patients **[35].**

Early markers of inflammation show important results. The VS in the 1st and 2nd hour are largely elevated compared to the controls. The presence of pollutants in the ambient air, which are produced by the cement plant, causes significant metabolic activity in the exposed inhabitants. This increase in ESR is one of the important signs of inflammation, this inflammatory syndrome is an evolutionary marker of many diseases.

The results of Erhaboor et al. (2013) indicated a significantly higher erythrocyte sedimentation rate among exposed workers relative to the unexposed controls. The ESR is a simple inexpensive valuable tool for

diagnostic purposes and to measure inflammation. The ESR remains fairly constant in healthy subjects and is affected by properties of the erythrocytes and plasma (Sultane et al, 2002; Erhabor et al, 2013).

We observed a significantly higher ESR among exposed staff compared to un-exposed controls. The ESR is a simple, inexpensive and it is especially valuable for diagnostic and prognostic purposes in silent illness including chronic diseases. The erythrocyte sedimentation rate (ESR), also called a sedimentation rate or Westergren ESR. It is the rate at which red cell sediment when contained in a vertical tube over an hour period. It is a common and non-specific hematology test often used as a measure of inflammation. The ESR remains fairly constant in healthy persons and is affected by properties of the erythrocytes and plasma and by mechanical or technical factors **[8].**

In general, the ESR is high when there is an infectious disease or a significant amount of tissue necrosis. It may also be increased in localized infections, tuberculosis, and malignant tumors with necrosis. High ESR is often associated with an infectious disease or a significant amount of tissue necrosis. It may also be increased in localized infections, tuberculosis, and malignant tumours with necrosis **[34].**

The result indicated that there was a significant increase in blood urea in the serum of cement factory workers. The creatinine also increased with increasing exposure time.

The increase might be due to the tendency of urea enhancing protein catabolism together with accelerated amino acid deamination for gluconeogenesis, on the other hand, the elevated levels of urea might be due to the destruction of red blood cells **[65].**

And any malfunctioning in glomerular filtration results in the retention of substances including urea **[15].**

The increase might be due to the fact that ammonia formed from the oxidative deamination of amino acids is converted to urea by enzymes in the liver and then excreted in the urine by the kidneys, thus any change occurred in these enzymes (ALT, AST, LDH, ALP, ect.) **[77].**

may accelerate the delivery of amino acids to the liver which can enhance urea nitrogen formation and increase the BUN/Creatinine ratio **[59].**

The changes may occurred in blood urea and creatinine can be considered suitable prognostic indicators of renal function in biomonitoring studies on workers exposed to occupational hazards **[33].**

The result showed a significant increase in blood glucose and also in triglyceride levels in the exposed subjects compared to the controls in this study.

Total cholesterol, triglycerides, LDL-cholesterol, VLDL-cholesterol, HDL-cholesterol, glucose and creatine kinase MB levels are significantly higher in cement workers compared to controls. This suggests that cement workers may be predisposed to cardiovascular disease **[62].**

when blood glucose levels rise, especially when they rise for a long duration, as blood sugar can be toxic to the body, including the cardiovascular system. Uncon- trolled diabetes with high glucose levels in the blood contributes to raising cholesterol and triglyceride levels **[67].**

conclusion

CONCLUSION

The present study has shown that occupational exposure to cement dust has a significant effect on hematological parameters. In individuals working in places containing cement dust in the environment, post-work shift blood samples in comparison to pre-shift samples showed a significant increase in PLT and WBC differentials like lymphocytes. Parameters pertaining to RBC like RBC count and PCV significantly increased, so also there was a noted increase in platelet count.

Therefore, the present study indicates that the hematological parameters are acutely affected by exposure to cement dust.

Based on the aforementioned results we concluded that workers of Elma Labiod cement factory were exposed to cement dust:

1. The hematological indices showed a significant increase in WBC, PLT, LYM, and RBC, indicating a toxic effect of the cement dust on the workers.

2. The observed differences in the hematocrit and mean corpuscular hemoglobin concentration between the exposed and unexposed cement factory workers were statistically significant in this study.

such as exposure to cement dust is capable of inducing free radicals, and marked hazardous alterations in some enzymatic activities, liver functions, and some biochemical parameters.

This study underscores the need for continuous environmental monitoring, use of personal protective equipment, and medical examination of Elma Labiod factory workers to promote health and safety at work.

Furthermore, support for this conclusion comes from the study that there should be supplementation of cement workers with antioxidant vitamins such as ascorbic and μ-tocopherol, which can improve plasma antioxidant enzymes.

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