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MINISTRY OF INDUSTRY

INDUSTRIAL POLLUTION PROJECT

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الجمهورية اللبنانية
مكتب وزير الدولة لشؤون التنمية الإدارية
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Republic of Lebanon
Office of the Minister of State for Administrative Reform
Center for Public Sector Projects and Studies
(C.P.S.P.S.)

INDUSTRIAL RESEARCH INSTITUTE

EXECUTIVE SUMMARY

1.1 Background

The region of Zouk Mosbeh has a high concentration of industries combined to a flagrant lack of public infrastructure in the domains of sewage system and solid waste collection. The important level of pollution estimated in the area has led the Ministry of Industry to investigate the degree of pollution that these industries are generating in the aspects of wastewater, solid waste and air emissions.

1.2 Objectives

The objectives of the study are to: Investigate and evaluate the degree of pollution generated by various industries in the Zouk Mosbeh Industrial Zone. Recommendations are to be proposed according to the study findings.

1.3 Organisational arrangements and responsibilities

The Ministry of Industry, after consultations with the Industrial Research Institute, proposed a list of 28 industries to be investigated. Sampling and laboratory analysis are to be performed on industries that generate wastewater effluents. The Ministry confided the task of achieving the study to the Industrial Research Institute.

1.4 Findings

- The analytical work performed within this project revealed that the actual weight of pollutants releases, mainly to water, goes deeper than just visual aspects. In fact, most of the parameters analysed for the selected industrial sites fall outside the Environmental Limit Values (ELV) set by the Ministry of Environment in its standard for wastewater.

- Important loads of phosphorus, organic matter, sulfides, suspended solids and oils are being discharged directly to seawaters on a continuous basis; which will lead on the long run to saturation levels and chronic impacts on environment and health.

- More than half of the industries surveyed dispose used paper and cardboards along with domestic wastes. In the same way, almost 40% of them dispose wood wastes in the same manner.

-The disposal of industrial liquid effluents into uncontrolled septic ditches is a common practice and its effect to soil and ground waters can be considerably high. Even when the septic ditches are emptied, the final destination of these effluents is unknown even for municipal authorities.

- Absence of a controlled industrial landfill. One industry located in the area of study treats some of its wastewater prior to disposal. However, this industry is obliged to discharge the solid residues emanating from the treatment in seawater despite the possibility of removing it.

- The power plant at Zouk Mosbeh is an important source of air pollutants, mostly sulfur dioxide, particulate matters and organic compounds. Despite the availability of national standards for fuel oil, these standards are not being enforced and the sulfur content of fuels can go as high as 5% or above.

1.5 Recommendations

- Implementing good housekeeping practices will highly improve the environmental situation of the selected industrial facilities.

- The concept of water reuse and recycling should be considered within the facilities.

- Waste avoidance/minimization is the preferred choice in all-appropriate cases, including the substitution by others that generate less hazardous waste.

- Many of the industries may need extra support from national authorities to understand environmental issues and their impacts.

- Creation of a data bank or channels to collect wastes that have added values (such as glass, paper, etc) and distribute them to recycling facilities.

- Disposal of used motor oils into sewers should be avoided. The establishment of a recycling facility for used oils should be considered as the best choice for waste management.

- The implementation of a biological treatment facility could be an option for handling the wastewater effluents generated by the industries and the residential areas.

- A regular monitoring program should be enforced to maintain a detailed control on the operations and emissions of the Zouk Mosbeh power plant. Air monitoring is also strongly suggested within the facilities in order to control stack emissions.

- Governmental institutions should implement at once the enforcement of the national standards for air and water quality (monitoring), as well as routine audits and inspections that will allow the detection of risks and to prevent the aggravation of pollutant releases.

-Effective collaboration from key stakeholders (industrialists, Ministries of environment, health and research centres) is a key issue for achieving environmental quality.

ملخـــــــص إجرائـــــــي

١-١- أرضيـــــة الصـــــورة

تمتلك منطقة ذوق مصبح مجمعاً صناعياً ضخماً ضمن مساحة تفتقر فيها البنية التحتية الرسمية من حيث المجارير وتجميع النفايات الصلبة الى الكثير لتجاري المتطلبات العصرية. إن إرتفاع نسبة التلوث في هذه المنطقة قد حدا بوزارة الصناعة الى إستقصاء مقدار هذا التلوث الناتج عن هذه الصناعات سواء في المياه المبتذلة، في النفايات الصلبة أم في الإنبعاثات الهوائية.

١-٢- الأهـــــــداف

إن أهداف هذه الدراسة هي تقدير نسبة هذا التلوث الصادر عن الصناعات المختلفة في منطقة ذوق مصبح الصناعية. عند إكتمال هذه الدراسة ستصدر التوصيات المناسبة.

١-٣- الترتيبات التنظيمية والتكليف

بعد إستشارة معهد البحوث الصناعية إقترحت وزارة الصناعة الكشف على ٢٨ مصنعاً في هذه المنطقة. تمت الدراسة بأخذ عينات من النفايات السائلة من هذه المصانع وفحصها.

كلف معهد البحوث الصناعية القيام بهذا العمل وتنفيذ كامل الدراسة.

١-٤- النتائـــــج

- أظهرت نتائج الفحوص أن كمية المخلفات الملوثة هي أكثر مما يظهره المياه. في الواقع أثبتت التحاليل على معظم العينات المأخوذة من هذه المنطقة الصناعية أن نسبة تلوث النفايات السائلة تفوق المعدل العام (ELV) المسموح به من قبل وزارة البيئة.
- وجدت كميات كبيرة من الفسفور، من المواد العضوية، من المشتقات الكبريتية ومن الأجسام الصلبة والزيوت من هذه العينات. كل هذه المواد تهدر مع المياه المبتذلة الى البحر. إن مياه البحر تصبح مع الوقت مشبعة بهذه المواد الضارة للصحة العامة وللبيئة.
- أكثر من نصف المصانع ترمي النفايات الورقية والكرتونية والخشبية مع النفايات المنزلية.

- إن صرف النفايات السائلة في قنوات غير مراقبة هو أمر مألوف في هذه المنطقة. تسير هذه المياه الى إتجاهات غير محددة وغير مصروفة حتى من قبل سلطة البلديات. إن هذا قد يضر بالتربة وبالمياه الجوفية.
- غياب مكبات للنفايات. إن عدم وجود مثل هذه المكبات قد يحدو بالصناعي ولو أجرى تصفية للنفايات السائلة أن يعود ويرمي المواد الصلبة المصفاة في مياه البحر.
- يعتبر معمل الذوق الحراري لتوليد الطاقة مصدراً كبيراً لتلوث الهواء، إذ ينفث الغازات السامة مثل ثاني أوكسيد الكبريت والدخان والمركبات العضوية. رغم وجود مواصفات وطنية "للفيول أويل" لا تلتزم هذه المؤسسة بتطبيق هذه المواصفات كلياً. إن حريق هذه الفيول الملوث قد يرفع نسبة ثاني أوكسيد الكبريت في الهواء الى أكثر من ٥%.

١-٥- <u>التوصيـــــــات</u>

- الإلتزام بالنظافة وبالصيانة التامة داخل المصانع وعدم رمي المواد المضرة في المياه المبتذلة قد يساعد على تحسن الوضع البيئي.
- يجب التركيز على إعادة إستعمال المياه المستعملة بعد تنظيفها.
- عدم ترك نفايات صناعية. إن تقليل هذه النفايات في التصنيع أو إبدال المواد المصنعة بمواد أخرى لا تترك إلا القليل من النفايات قد تكون الوسيلة الفريدة لتخفيف التلوث البيئي.
- يحتاج الكثير من الصناعيين الى مساندة من السلطات الوطنية لتفهم مستلزمات الصون من التلوث البيئي في التصنيع.
- إستحداث مركز معلومات لتجميع ونقل النفايات تم فرزها من المواد المزادة كالزجاج والورق والبلاستيك وغيرها.
- يجب منع رمي زيوت المحركات المستعملة في مجاري المياه. لهذا وجب إيجاد وسيلة لتكرير هذه الزيوت وإعادة إستعمالها.
- إن المعالجة البيولوجية للمياه المبتذلة للمناطق الصناعية والسكنية قد تكون وسيلة لتخفيف التلوث البيئي.
- يجب وضع برنامج تطبيقي إلزامي لمنع التلوث لمعمل الذوق الحراري وذلك بإلزام إستعمال فيول مطابق للمواصفات الوطنية وإلزام مراقبة وفحص الإنبعاثات الهوائية.

- على المؤسسات الحكومية وضع برنامج للعمل على إلزامية تطبيق المواصفات التي تخص جودة الهواء والماء، وبرنامج للمراجعة والمراقبة لكشف جميع الشوائب التي قد تؤدي الى كارثة بيئية.
- إن تعاون جميع الأطراف ومنهم: الصناعيون، وزارة البيئة، وزارة الصحة، مراكز الأبحاث، إلخ... هو مفتاح الحل لإيجاد مناخ بيئي سليم.

RESUME

1.1 Contexte

La région de Zouk Mosbeh enregistre une concentration élevée d'industries associée à un manque flagrant au niveau de l'infrastructure; à savoir, un système d'égouts inexistant et une collection de déchets solides déficiente.
L'important niveau de pollution estimé dans la région à conduit le Ministère de l'Industrie à enquêter sur le degré de pollution engendrée dans les différents aspects environnementaux des déchets liquides, solides et des émissions dans l'air.

1.2 Objectifs

Les objectifs de cette étude se résument à évaluer le degré de pollution engendrée par les différentes industries situées dans la zone industrielle de Zouk Mosbeh. Des recommandations seront proposées suivant les conclusions de l'étude..

1.3 Arrangements organisationnels et responsabilités

Une liste comprenant 28 industries à enquêter à été proposée par le Ministère de l'Industrie, après des consultations effectuées avec l'Institut de Recherche Industrielle. Des analyses de laboratoire devront être effectuées sur des échantillons prélevés sur des industries qui gênèrent des effluents liquides. La tache d'effectuer cette étude a été confiée par le Ministère a l'Institut de Recherche Industrielle.

1.4 Conclusions

- Les résultats de l'enquête et des analyses de laboratoire ont révélé que la composition des déchets liquides émis constitue une bien plus grave source de préoccupation que leur aspect visuel. En effet, dans la majorité des sites sélectionnés, les résultats des analyses ont dépassé les normes fixées par le Ministère de l'Environnement dans presque tous les paramètres analysés.

- Des teneurs importantes de phosphore, de matières organiques, de matières en suspension et des huiles sont déchargées continuellement directement dans la mer, ce qui mènera à long terme, à des niveaux de saturation qui auront des impacts chroniques sur la santé et l'environnement.

- Un pourcentage assez élevé (40-50%) des industries visitées procèdent au rejet des papiers, des cartons et du bois avec les déchets domestiques, quand les possibilités de recyclage sont disponibles.

-Les effluents industriels liquides sont déchargés dans des fosses septiques. Ceci peut avoir un impact considérable au niveau de la qualité de l'eau et du sol. Il est à noter que les fosses sont régulièrement vidées, mais la destination finale de leur contenu reste indéterminée.

- L'absence d'une décharge industrielle contrôlée conduit certaines industries à se débarrasser des déchets solides avec leurs effluents liquides, au moment ou ils peuvent être enfouis dans des sites spécialement conçus a cet effet.. A titre d'exemple, une industrie située dans la région traite les effluents liquides avant leur rejet, en réduisant le chrome VI, nocif, généré par son procédé de fabrication, en Chrome III moins dangereux pour l'environnement. Toutefois, celle-ci est obligée de décharger dans la mer les résidus solides constitués de chrome III provenant du procédé de traitement, ne disposant pas d'un espace d'enfouissement autorisé à cet effet.

- La station électrique de Zouk Mosbeh est une source importante de pollution atmosphérique, principalement à cause des émanations de dioxyde de soufre, de particules et de composés organiques. Les standards nationaux concernant le Diesel ne sont pas appliqués et la conteneur en soufre peut dépasser les 5%.

1.5 Recommandations

- Améliorer les pratiques d'une gestion interne propre au sein des industries, contribuera grandement a l'assainissement de la situation environnementale des installations industrielles sélectionnées.

- Le concept de réutilisation et de recyclage de l'eau utilisée dans le processus de fabrication doit être considéré.

- La minimisation des déchets constitue la meilleure option dans tous les cas appropriés. Cette minimisation peut inclure la substitution des produits utilisés par d'autres qui génèrent des déchets moins dangereux.

- Les autorités compétentes doivent apporter leur soutient aux industries pour mieux les aider à comprendre les questions environnementales et leurs impacts.

- La création d'une base de données pour rassembler les déchets recyclables paraît nécessaire pour aider les industriels a se mettre en contact avec les réseaux de recyclage.

- Le rejet des huiles usées doit être évité. Une usine de recyclage des huiles usagées doit être considérée comme le meilleur choix pour la gestion de ce type de déchets.

- L'installation d'une station de traitement des effluents est une nécessité.

- La mise en oeuvre d'un programme pour maintenir un contrôle régulier des opérations et des émissions de la station électrique de Zouk Mosbeh.

- Les institutions gouvernementales doivent veiller á l'application des normes nationales concernant la qualité de l'air et de l'eau. Des audits et des inspections régulières permettraient à la fois la détection et la prévention des risques.

- Une collaboration effective entre les industriels, les Ministères concernés et les centres de recherche est essentielle pour atteindre une meilleure qualité environnementale.

Industrial Pollution Study – Zouk Mosbeh

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List of Acronyms

BOD: Biochemical Oxygen Demand
COD: Chemical Oxygen Demand
TSS: Total Suspended Solids
TKN: Total Kjeldahl N
NH_3 – N: Ammoniacal Nitrogen
P: Phosphorous
S: Sulfides
NO_3: Nitrates
Pb: Lead
Cu: Copper
Cr: Chromium
Zn: Zinc
Ag: Silver
As: Arsenic
PM: Particulate Matter
POM: Polycyclic Organic Matter
SO_x: Sulfur oxides
NO_x: Nitrogen Oxides
N_2O: Nitrous oxide
CO: Carbon monoxide
VOCs: Volatile organic compounds
PAH: Polynuclear Aromatic Hydrocarbons
ELV: Environmental Limit Values

1. INTRODUCTION

1.1 General context

Zouk Mosbeh industrial zone regroups a high concentration of industries that varies from small factories with out-of-date technologies to modern plants that use the latest technologies. The region lacks of a sewage infrastructure and an efficient solid waste collection system. Wastewater coming from the various industries is released partly in a public channel that flows directly into the nearby Mediterranean Sea, and partly into private septic tanks that a significant number of which have unlined bottom permitting to wastewater to be potentially in direct contact with underground fresh water sources. Moreover, the deficiency in monitoring in the environmental aspects of wastewater, solid waste and air emissions, have lead to serious environmental impacts in the above-mentioned aspects.

In order to assess the degree of pollution that these industries are generating, the Ministry of Industry confided this task to the Industrial Research Institute, with the final aim of suggesting appropriate recommendations according to the area environmental diagnosis.

The study was launched on the 14th of November 2002. It involves the sampling and laboratory analysis of 28 selected Industries representing the industrial sector in Zouk Mosbeh.

1.2 Scope of the project.

1.2.1 Project objectives

The main objectives of the project can be summarized in the three following points:

- Assess the degree of pollution that the industries are generating in the environmental aspects of wastewater effluents, solid waste and air emissions.
- Evaluate the industrial pollution generated by the industries against the pollution generated by the most polluting commercial establishments.
- Propose and recommend methods in order to reduce the environmental impact of this pollution.

1.2.2 Area of study: overview

1.2.2.1 Population and geographical information

Zouk Mosbeh is located at 15 km to the north of Beirut. It is surrounded to the west by the Mediterranean Sea, to the East by the villages of Antoura and Mazraate el Rass, to the North by Zouk Mikhael, and to the south by the Nahr El Kalb River. Its total area is about 4 258 499 m^2 for a population of about 50 000, giving a density of 11 740 persons per km^2. The number of legally affiliated industries to the Association of Lebanese Industrialists is about 52. But in fact the real number of industries is slightly above this figure, and a total of about 68 were counted in this survey.
The industrial enterprises employ around 5000 to 6000 workers per day, which represents 10 percent of the total population resident in this municipality.

1.2.2.2 Industry overview

The area of Zouk Mosbeh regroups one of the highest concentrations of industries in Lebanon. It comprises old industries with out-of-date technologies, as well as new ones that use relatively modern technologies. The old industries, some of them established during the sixties, are mostly medium and small-scale industries, and are distributed throughout the area of study. Their production technologies are backward (Though efficient and relatively with cheap costs) causing pollution of air, water environments, and discharging solid wastes into the surrounding areas. Nearly all the old enterprises do not have any wastewater treatment system. Therefore, Industrial wastewater is only treated superficially, and then discharged directly into the surface water sources, causing direct pollution to the nearby Mediterranean Sea.
The industrial solid wastes are sometimes separated form domestic waste, but no legal requirements oblige the enterprises to do so. Sorting of industrial waste is made in most cases with the final aim of selling the waste to third parties for recycling purposes.
Regarding new industries, modern technologies are used, but the lack of municipal sewer system causes to discharge waste effluents directly into a public channel that flows into the sea. Some of the industries are equipped with industrial wastewater treatment facilities. However, this is not generalized to all industries and is confined only to few. Pollution control measures such as cleaner production options and environmental impact assessment are rather embryonic, and in most cases the assessment of environmental impacts is still neglected.

1.2.2.3 Sources of pollution

There are several categories of pollution that are generated in Zouk Mosbeh industrial zone:

- Industrial effluents emanating from small factories and industries in the industrial area.
- Raw sewage from some factories that open their sewage channels at night.
- Domestic effluents from nearby residential areas. Sewage is drained from septic wells and sometimes poured in a public channel that flows directly into the sea.
- Effluents from petrol stations and garages.
- Solid wastes / garbage generated from industries and nearby residential areas.
- Air pollution emitted by the nearby electrical power plant of Zouk, private generators and traffic.

1.2.2.4 Pollution profiles

From the pollution profiles of Zouk Mosbeh industrial zone, it is evident that the main pollution is generated by the industries and small factories located in the area as well as from small businesses like oil stations, garages and other repair shops. It is very difficult to assess at which time of the day the pollution reaches its peak, since industries and small businesses have different production processes. However, it was noticed that the public channel that drain a substantial part of the wastewater generated in the area of study is mainly active early in the morning and around 2 or 3 o'clock in the afternoon. It is possible to tell by looking at the profiles, at what point a dose of pollutant has been injected into the channel and hence to establish its origin. Nevertheless, the source of the pollutants poured in the channel could not always be determined due to the multiplicity of sewage outlets that are connected to the channel. This subject will be approached in more details in the samples analysis section.

1.3 Methodology

1.3.1 Dividing industries by sector of activity

The industries under study were divided into categories as follows:

- Textile
  - Filitex (25)
  - Colortex (27)
  - Abdel Nour (26)

- Electroplating
    - Sidem (6)
    - Habis (15)
- Dry cleaning
    - TAG sarl (Abdel Massih laundry) (7)
    - La primera (8)
- Pharmaceutical
    - Algorithm (24)
- Food
    - Adams- Warner Lambert (1)
    - ZM Vegetable oil (2)
    - Meptico (3)
- Paper
    - Ninex (16)
- Detergents
    - Societe Libano-Italienne (23)
    - Henkel (22)
- Marble
    - Hcheimy (13)
    - Azar Karam (12)
- Wood
    - Sahaco (9)
    - Many Doro (17)
- Printing press
    - Luna Printing Press (10)
    - United Printing Press (11)
- Aluminum
    - Ajax (5)
    - Snam (4)
    - Arcotechnique (14)

- Plastics
  - API (21)
  - Masterpak (20)

- Perfumes and cosmetics
  - Samoa (18)
  - Aromatics (19)

In order to facilitate site visits and analysis, the selected industries were divided into four groups; each group representing a sector of activity, activities that are similar in their scope of work, in their use of raw materials, or in the presence or absence of water in their production process.
The four groups were constituted as follows:

- Laundries, Chemicals and Derivatives and Textile (Group 1).
- Aluminum, Wood, Metal, Furniture (Group 2).
- Paper, Plastic, Paints, Tanning, Pharmaceutical (Group 3).
- Food, Printing Press, Marble, Perfume (Group 4).

1.3.2 Site visits

Interviews and shorts audits were conducted with the relevant managers. Each facility was reviewed with respect to the environmental impacts of its activities with the final aim of identifying the major sources of pollution involved in its production process.
Some of the industries selected by the Ministry of Industry were found closed (Société Libanaise pour l'Industrie des Peaux), some not operating in the area (The Sons of Michel Boutros Company and Polytextile) while others showed little activity (Aromatics, Imad Shoueiry Est.). The final number of the selected industries settled to 27.

The following aspects were considered:

- Process and operation of the facility.
- Nature of raw materials and chemicals used.
- Water consumption.
- Quantities and nature of solid waste, wastewater and air emissions.
- Recycling possibilities.

Site Plan


N
Intersection Channel
Commercial Establishment
Industries
Industrial Zone
Zouk Mosbeh
50
0
50
Meters

1.3.3 Evaluating other sources of pollution: Garages, paint shops and repair shops

A brief checklist was prepared in order to evaluate solid waste and wastewater pollution generated from repair shops. The questionnaire included information about the quantity of wastewater generation, solid waste generation, hazardous waste generation, final destination of waste, and recycling possibilities. The number of the businesses visited was about 20, and comprised nearly all the businesses of this category present in the area of study.

1.3.4 Sampling

1.3.4.1 Sampling process

Water samples were collected mainly into the end-of-pipe of the production processes and from baths that are eventually dumped into sewer or septic tank. Samples were also taken outside plants at the sewers collection lines as well as at a public channel that collects effluents coming from several plants. Samples were collected in suitable glass and plastic containers and properly preserved prior to analysis.

1.3.4.2 Sampling sites

Samples were taken from industries that generate wastewater effluents. The considered industries were selected as follows:

Group 1: La Primera, TAG sarl (Abdel Massih laundry), Henkel Lebanon, Société Libano - Italienne, Filitex, Colortex, Nakhle Abdel Nour and Sons.

Group 2: Sidem, Habis Silver sal.

Group 3: Ninex, Algorithm.

Group 4: Adams – Warner Lambert, Z.M Vegetable Oils Industries, Azar Karam sarl, Hcheimy,

Samples were also taken from the intersection channel where the wastewater effluents of the following industries meet: Colorex, Filitex, Hcheimy and Henkel.

2. ANALYZED PARAMETERS: OVERVIEW

The most relevant parameters for the characterization of an effluent were analyzed, focusing mainly on:

- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- pH
- Total suspended solids (TSS)
- Total Kjeldahl N (TKN)
- Ammoniacal Nitrogen (NH_3 – N)
- Phosphorous (P)
- Oil & grease
- Sulfides
- Nitrates (NO_3)

Heavy Metals:

- Lead (Pb)
- Copper (Cu)
- Chromium (Cr)
- Zinc (Zn)
- Silver (Ag)
- Arsenic (As)

2.1 Biochemical Oxygen Demand (BOD)

Biological Oxygen Demand is an indication of the amount of oxygen consumed by biochemically decomposed organic matter in the water. The result indicates the amount of easily decomposable material in the water.
The Biochemical Demand (BOD) test measures the ability of naturally occurring microorganisms to digest organic matter, usually in 5-day incubation at 20°C, by analyzing the depletion of oxygen. This measures biodegradable organic matter. The BOD analysis is an attempt to simulate the effect a waste will have on the dissolved oxygen of a stream. The test gives an indication of the amount of oxygen needed to stabilize or biologically oxidize the waste. The BOD_5 test is widely used to determine the degree to which a waste stream will contribute to pollution of receiving waters by depriving organisms in those waters of their source of oxygen. The BOD_5 test is of prime importance in regulatory programs and in determining the overall health of receiving waters.

2.2 Chemical Oxygen Demand (COD)

Chemical Oxygen Demand is the amount of oxygen required to degrade the organic compounds of wastewater. The bigger the COD value of wastewater, the more oxygen the discharges demand from water bodies.

The Chemical oxygen demand (COD) test gives a good estimate of the first stage oxygen demand for most wastewater. High COD values are mainly caused by organic matter in the water. An advantage of the COD test over the BOD is 2 to 3 hours versus 5 days. The COD test should be considered an independent measurement of organic matter in a sample rather than a substitute for the BOD test.

2.3 Suspended Solids

Solids may be insoluble and suspended in the water or they may be dissolved in the water. The suspended solids determination is one of the major parameters used to evaluate the strength of wastewater.

2.4 pH

pH is the scale used to express the quantity of acid present in a water solution. Total alkalinity analysis is performed by measuring the amount of acid needed to reduce the samples pH to a certain value. The alkalinity determination is a useful tool in calculating chemical dosages needed in coagulation and water softening. Alkalinity must also be known to calculate corrosives and to estimate the carbonate hardness of water. An increase in pH increases the ammonia toxicity to aquatic life. Lowering of pH increases the cyanide toxicity.

2.5 Total Kjeldahl Nitrogen (TKN)

Total Nitrogen is the sum of nitrate (NO_3), nitrite (NO_2) organic nitrogen and ammonia (all expressed as N).Thus, the term Kjeldahl nitrogen refers to organic plus ammonia nitrogen. When the concentration of these nutrients consistently exceeds natural levels, a nutrient imbalance is produced. This imbalance can lead to undesirable changes in the biological community and can drive an aquatic system into an accelerated rate of eutrophication. Typically, the eutrophication process leads to a change in the structure of the algal community, including severe algal blooms for extended periods of time.

The compounds of nitrogen are of interest to the wastewater treatment plant operator because of the importance of nitrogen in the life processes of all plants and animals.

Sampling Sites

Ammonia, organic nitrogen, nitrate, and nitrite are the most important nitrogen forms in wastewater treatment.

2.6 Ammoniacal Nitrogen

Ammonia in water is usually related to sewage being found in the system.

2.7 Phosphorous

Because of the importance of phosphorous as a nutrient in biological methods of wastewater treatment, its determination is essential with many industrial wastes and in the operation of waste treatment plants. However, phosphate in an impoundment leads to algae blooms (Eutrophication).

2.8 Sulfides

It is a product of the anaerobic decay of organic matter containing sulfur. It is also produced in the anaerobic reduction of sulfate by microorganisms and is evolved as a gaseous pollutant from geothermal waters. Its presence is detected by its characteristic rotten-egg odor. The sulfide ion has tremendous affinity for many heavy metals, and precipitation of metallic sulfides often accompanies production of H_2S.

2.9 Temperature

Temperature is one of the most frequently taken tests in the water/wastewater industry. Accurate water temperature readings are important because of its influence on biological growth, dissolved gas concentrations and chemical reaction rates. Chemical reactions speed up when the temperature is increased.

2.10 Oil and Grease

The term oil is meant to indicate a water insoluble organic material that is a liquid at room temperature. The term grease means a water insoluble organic material that is a solid or semi-solid at room temperature. The insoluble organic materials are of concern. Aside from any specific toxic effect due to ingestion of a particular component of the mixture, insoluble organic material can present environmental problems. Most persons are familiar with the pictures of the results of oil spills on the fauna and flora in the immediate area, the oiled birds and dead sea otters, the coated rocks. Insoluble organic materials in effluent create the same problems only on a smaller case because of the smaller quantities. Even on this smaller scale they can cause death, coating the gill surfaces of fish, amphibians, insects and other creatures living in water, preventing the transport of oxygen from the water into the animal and interrupting respiration.

2.11 Heavy metals

Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers and groundwater. Heavy metals can have a negative impact on aquatic ecosystems, the food chain, and human health.

2.11.1 Chromium

Chromium is used in metal alloys and pigments for paints, cement, paper, rubber and other materials. Low-level exposure can irritate the skin and cause ulceration. Long term exposure can cause kidney and liver damage, and damage too circulatory and nerve tissue. Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium.

2.11.2 Copper

Copper is an essential substance to human life, but in high doses it can cause anemia, liver and kidney damage, stomach and intestinal irritation. People with Wilson's disease are at greater risk for health effects from overexposure to copper.

2.11.3 Lead

Lead is a dangerous element; it is harmful even in small amounts. It is found in trace amounts in various foods, notably fish, which are heavily subject to industrial pollution. Most of the lead we take in is removed from our bodies in urine; however, there is still risk of build up, particularly in children. If lead buildup occurs, health problems including damage to the nervous system, mental retardation, and even death can ensue.

2.11.4 Zinc

Zinc is employed to form numerous alloys with other metals. Large quantities of zinc are used to produce die-castings, used extensively notably in the electrical and hardware industries. Zinc is also used to galvanize other metals such as iron to prevent corrosion. Zinc oxide is widely used in the manufacture of paints, rubber products, cosmetics, pharmaceuticals, floors coverings, plastics, printing inks, soap, storage batteries, textiles and other products. Zinc is not considered to be toxic, but when freshly formed ZnO is inhaled a disorder known as the oxide shakes or zinc chills sometimes occur. However, zinc is considered to be toxic to plants at high levels.

2.11.5 Silver

Silver itself is not considered to be toxic. However, most of its salts are poisonous. Silver compounds can be absorbed in the circulatory system and reduced silver deposited in the various tissues of the body. Silver or soluble silver compounds can affect the body if they are inhaled or if they come in contact with the eyes or skin. Silver is used in electroplating, glass manufacture, and in medicine. It is also found in the composition of inks, dyes, powder pigments and paints and many other products. In the aquatic environment, mostly algae, daphnia, and fresh water mussels accumulate silver.

2.11.6 Arsenic

Arsenic and its compounds are poisonous. Inhalation of arsenic emissions may lead to lung cancer. Arsenic is used in the manufacture of bleaching powder, dye, paint, pigment, and paper. It is also found in silver refiners, textile printers, thinners, and metal manufacturers.

2.11.7 Aluminum

Aluminum is used in the manufacturing of printing inks, powders for alloys and paints. It is also used for packaging, cans and containers.... Electrolytic production of aluminum can lead to a substantial exposure to fluorides and carcinogenic tar oils including polyaromatic hydrocarbons.

3. SOLID WASTE GENERATION

The municipality, the industries and a private company make the collection of solid waste. During our visits to the region under study, we were not able to identify a fixed authority that could be in charge of solid waste collection. However it seems that a private company is collecting domestic wastes, while industrial wastes are being removed by industries on individual basis. The role of the municipality could not be determined in this matter.

Table 1 shows solid wastes and wastewater generation from commercial establishments, considered as a secondary source of pollution.

FACILITY	SOLID WASTES	LIQUID EFFLUENTS
Garage Georges Obeid	1 ton/month Not sorted Sold	3 L/month Discharged in a channel (paints + thinner)
Garage Gilbert Rahi	50 kg/month Not sorted Sold	- Sold (oil)
Garage Hanna Abdallah	- Not sorted Domestic waste	200 L/month Sold (oil)
Body Car	- Not sorted Domestic waste	1 L/month Discharged with domestic waste (Paints + thinner)
Garage Antoun Khalil	2-3 kg/month Not sorted Domestic waste	No liquid effluents
Garage Bou Akkar	- Sorted Cardboard: disposed of with domestic waste Metal: sold	30 L/month Sold (oil)
Georges and Najib Mouannes	500 kg/month Not sorted Sold	80 kg/month Sold (oil)
Garage Elie Akiki	1 kg/week Sorted Cardboard: disposed of with domestic waste Metal: sold	- Garbage (oil)
Boulos Kozah	50 kg/month Not sorted Domestic waste	- Sold (Paints + thinner)
Bechara Richa	300 kg/month Not sorted Sold	- Sold (oil)
Eddy Muffler	-	30-50 L/month

	Not sorted Sold	Sold (oil)
Dany Bou Sleiman	- Not sorted Domestic waste	5 L/month Discharged in a channel (thinner)
Georges Bou Merhi	- Not sorted Sold	4-5 L/month Sold (oil)
Georges Khoueiry	30 kg/month Not sorted Sold	20-30 kg/month Garbage (oil)
Anvers	50 kg/week Sorted Metal: sold Papers + empty boxes: disposed of with domestic waste	80-100 kg/month Discharged into sewers (oil, paints, thinner)
Simon Akiki	10 kg/month Not sorted Sold	40 kg/month Sold (oil)
Antoine Saadé	250 kg/week Sorted Metal: sold Cardboard: disposed of with domestic waste	200 L/month Discharged in a channel (oil)
Nouhad Haddad	- Sorted Metal: sold Cardboard + Empty boxes: disposed of with domestic waste	50 L/month Sold (oil)
Vahe Ghazar	- Sorted Metal: sold Cardboard + plastics + Empty boxes: disposed of with domestic waste	- Spread on the floor
Rabih Hassoun	- Not sorted Sold	- Sold (oil)

Table 1: Solid wastes and wastewater generation from commercial establishments.

3.1 Hazardous waste

No hazardous solid waste (hazardous By – products) is involved in the production process of the selected industries.

However, barrels and small containers that contain chemical residues are generated by some industries, namely in the textile, wood, plastic and detergents, and dry- cleaning sectors. In some cases they are being reused by the factory (sent to the furnisher for reutilization), sold for multiple use, or just thrown with domestic waste. Dumping and reutilization are made in unsafe conditions.

Facility	Solid wastes	Liquid effluents	Production
Filitex	Sorted Metal, wood, plastic, cardboard: Re used or Sold Textiles (50t/y): reused Domestic wastes: 30 t/y	300 m^3/day Discharged in a open air public channel Used oil: destination unknown, probably discharged with domestic wastes Dyes, suspended solids	450t/y
Henkel	30 t/y Sorted Wood, paper: Re used or Sold Plastic: recycled	8400 m^3/y Septic tank Discharged in a open air public channel Used oil: sold Phosphorous, suspended solids, sulfides	18000t/y
La Primera	Not sorted Disposed of off site	50 000 L/day Discharged in a channel Dyes, sulfides, phosphorous	24 t/y
Société Libano-Italienne	Sorted Paper, cardboard, plastic: Landfill Wood: sold	1 250 000 L Discharged in septic tank and open air public channel Used oil: sold Suspended solids, phosphorous.	2500t/y
N. Abdel Nour	Not sorted Textiles: landfill Cardboard: Sold	Discharged in open air public channel Domestic: 2000 L/day, Production: 3000 L/day Dyes, suspended solids Used oil: Sold	8t/y
Colortex	Sorted Plastic, textile, cardboard, Reused or disposed of off site	Suspended solids, dyes	3t/week
Snam	10 t/y Sorted Aluminum, wood, plastic Sold for recycling	-	50t/y
Many Doro	Sorted Wood, metal paint containers, plastic	Open ground septic tank Used oil: disposed of with domestic waste	-
Habis	Sorted Plastic: 1 barrel/day, cotton: 1 barrel / day (Landfill) Paper, cardboard: reused	432 000 L/year Septic tank Used oil: sold Sulfuric acid, caustic soda, traces	20t/y

		of silver, lead, KCN, sodium carbonate	
Sidem	5 t/month Sorted (Wood: 1 t/month) Iron, plastic barrels: sold Aluminum: reused Wood, paper, cardboard: landfill	1344 000 L / day Discharged in open air municipal channel Sulfuric acid, caustic soda, chromium Treatment for chromiumVI neutralization for sulfuric acid and caustic soda	13000t/y
Ajax	Industrial waste: 7 t/y Sorted Glass: sold PVC recycled EPDM, paper, wood, cardboard: landfill	-	-
Ninex	Plastic, cardboard, sold	Wastewater: Discharged in open air public channel Used oil: discharged in open air public channel Suspended solids	1100 t/y
Adams	Sorted Cardboard (300 kg/day), wood, glass, sugar: disposed of in landfill	Domestic: 25 000L/day Septic tank, and open air municipal channel Used oil: sold	2000t/y
Masterpack	Plastic (100kg/week), paper, cardboard Sorted Recycled or disposed of in Landfill	2000 L / day Septic tank Used oil: sold Dyes	8000t/y
API	15 t/y Sorted Polyethylene, recycled polypropylene, wood: sold	Connected to sewer system (with outlet connected to public channel) Used oil: sold	-
Algorithm	Sorted Paper, cardboard: 1 truckload/week Expired products: 1 truckload/week	5000 L/day Used oil: sold	-
Hcheimy	Marble Powder Reused in part Disposed of in landfill	Discharged in open air public channel Suspended solids	-
Samoa	Sorted Plastic, cardboard: sold	-	6t/y
Meptico	Metal, cardboard, recycled	-	-
ZM Vegetable oil	150 kg/day (100 kg/day as industrial waste) Sorted	35000 – 40 000 L/day Suspended solids, oil and grease, phosphorous, sulfides	16000t/y

	Disposed of off site		
Aromatics	3 barrels /month Metal Disposed of in landfill	Open ground septic tank Used oil: discharged in septic tank with wastewater	-
Azar Karam	12- 15 m^3 /week (in volume) Sorted Marble powder: Landfill Part is reused	5000 L/day Septic tank Used oil: disposed of with solid waste (landfill)	1200t/y
Sahaco	50 kg/day Metal barrels, wood: Landfill Not sorted	100 L/day Discharged directly on ground surface	-
Luna Printing press	Paper, cardboard, wood, textiles Not sorted	Open ground septic tank Dyes	-
United printing Press	Paper: recycled off site Cardboard, Textiles, Wood: Landfill Not sorted	Wastewater: Septic tank Used oil: sold to oil stations Dyes	-
Arcotechnique	Sorted 2-4 t/y (Aluminum, glass, plastic) 300- 400 kg/year Domestic Aluminum: recycled off site Glass, plastic: landfill.	Domestic wastewater Connected to open air municipal channel	70 t/y

Table 2: Solid wastes and wastewater generation from visited industrial sites.

3.2 Non-hazardous waste

3.2.1 Solid waste composition

The solid wastes are generated in high quantities by most of the industries, and mainly constituted of wood, paper, cardboard, plastic, textile, glass and metal. The municipality is in charge of their disposal, as well as the industries themselves, and a private company. Final destination is authorized landfills (private company and municipality), or unknown (industries).

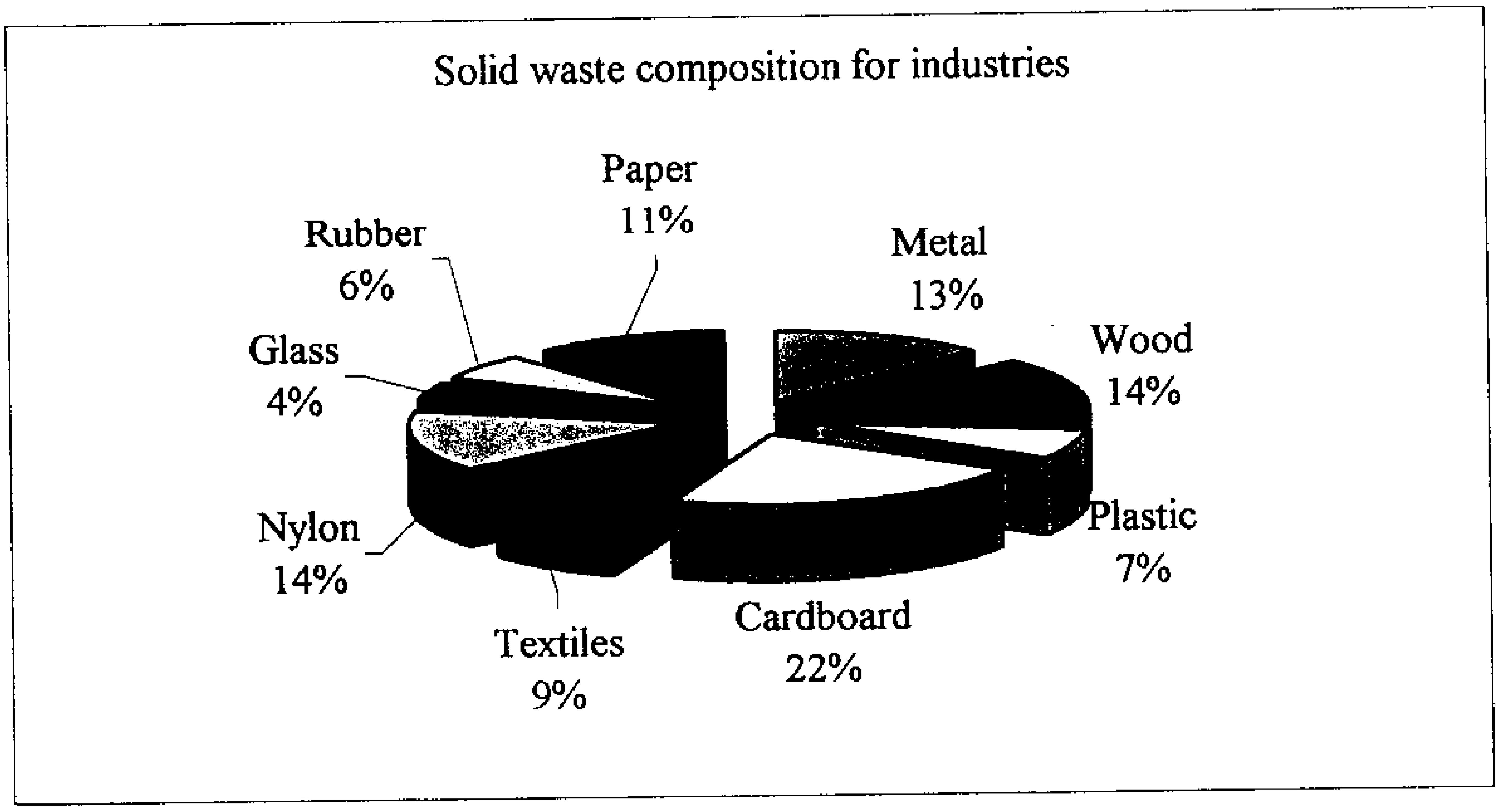

Figure 1: Solid waste composition of visited industrial sites.

3.2.2 Sorting of solid waste

In some cases (29%), sorting of waste is made at source (Filitex, Masterpak, Sahaco, Henkel, Ajax, API) for reutilization or recycling purposes; but in most other cases (71%), dumping of waste is made without any sorting. Concerning the repair shops, about 65 % do not sort solid waste prior to disposal, while 35 % do. The explanation behind these reversed figures between industries and commercial establishments might lie in the fact that solid waste is generated in much higher quantities in industries, inducing these latter to find new paths for their disposal. Another explanation might be the fact that environmental awareness is more developed in industries than in small businesses.

On the other hand, it was not possible in most of the visited plants to determine the quantities of solid waste generated. Some figures could be obtained from the repair and oil service shops, though they seem not in accordance with each other, and some doubts must be thrown on their reliability.

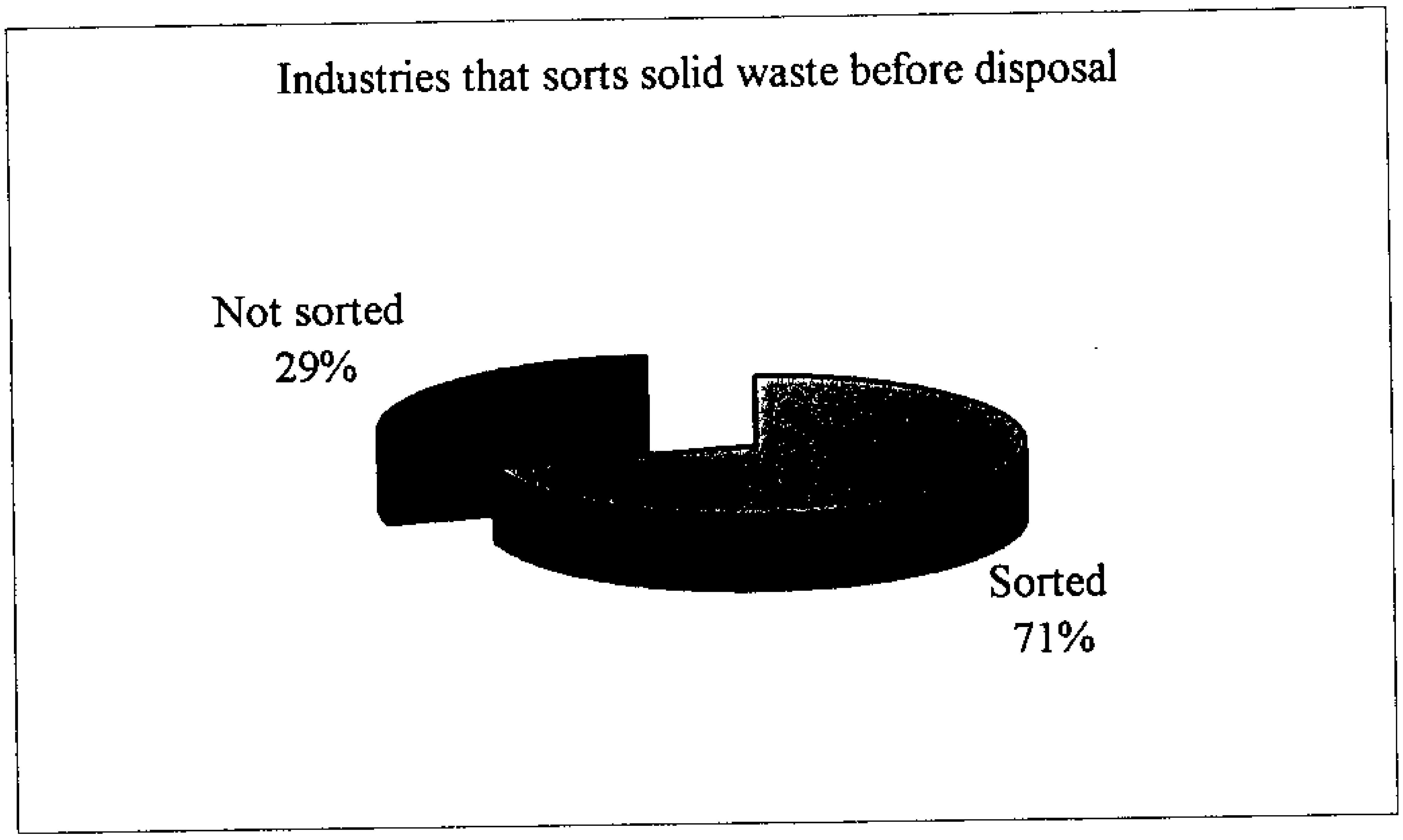

Figure 2: Sorting of waste before disposal (Industries)

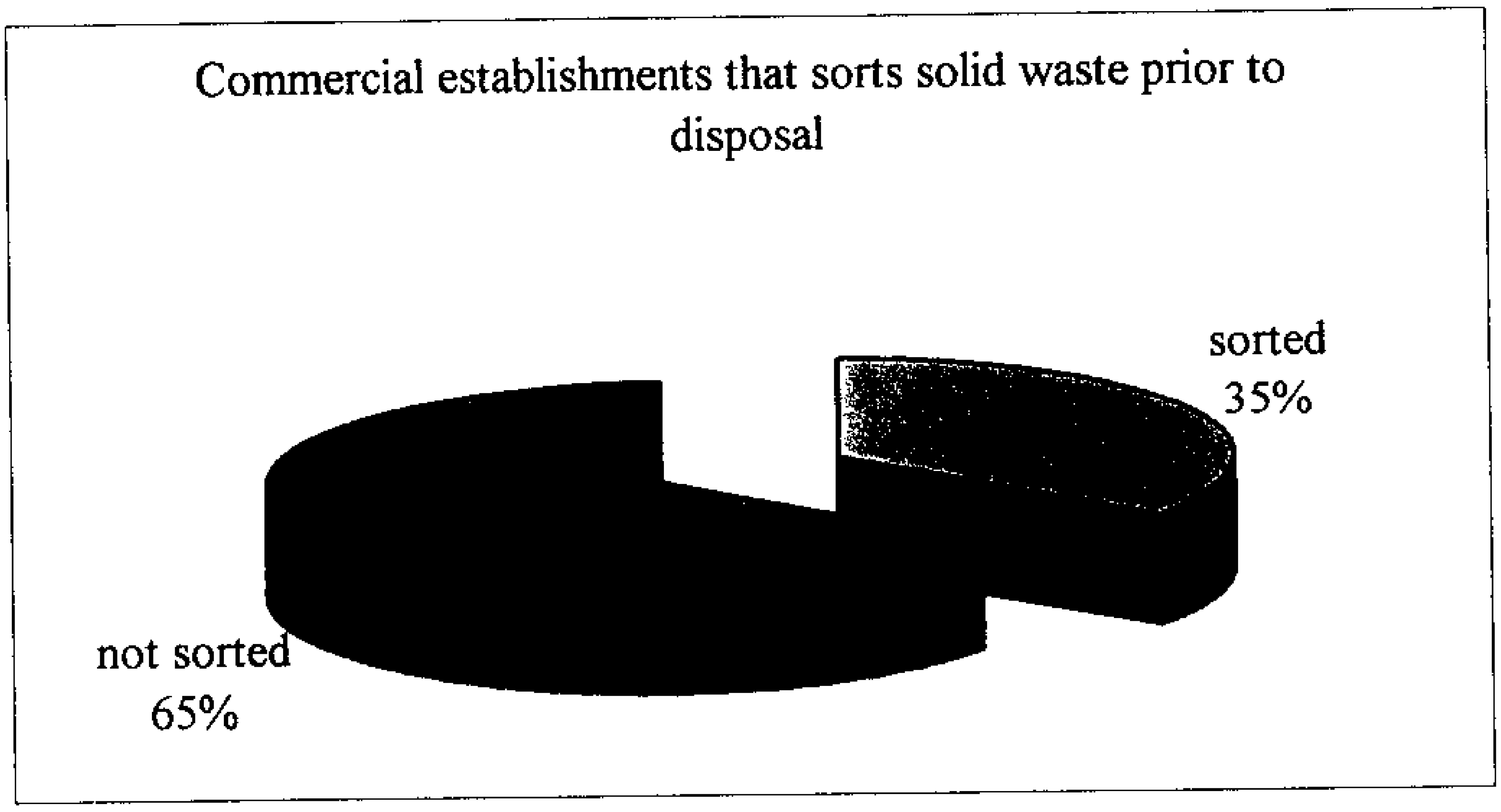

Figure 3: Sorting of wastes before disposal (commercial establishments).

3.2.3 Solid waste destination

During the data-screening phase, four paths of solid waste handling were identified:

- Discharging in landfills
- Reutilization
- Recycling
- Selling to third parties

Selling of solid waste could be included in the reutilization path, however since it involves an off site use, we found it more convenient to mention it separately.
The destination of each kind of solid waste generated by the industries can be schematized as follows:

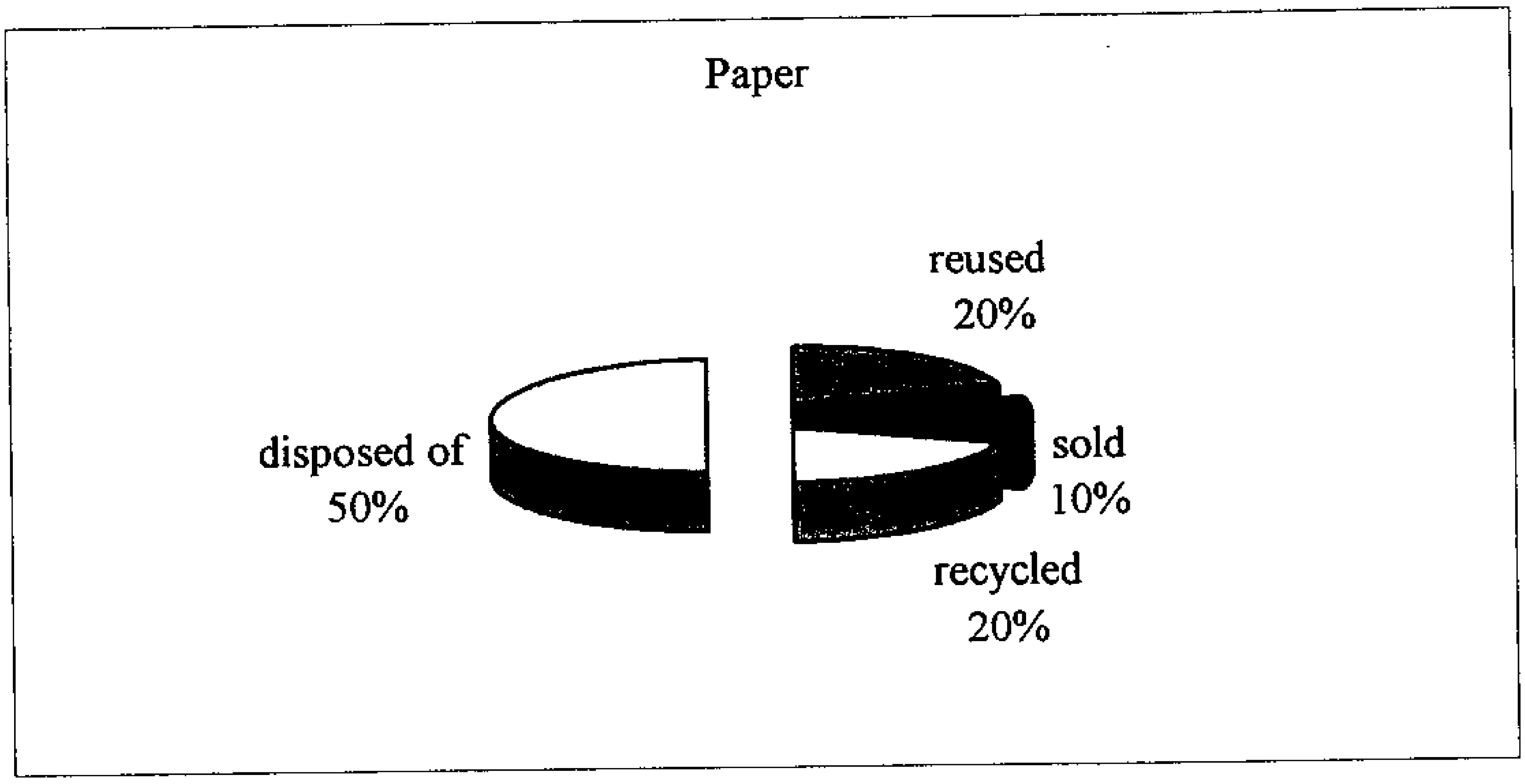

Figure 4: Handling of paper wastes.

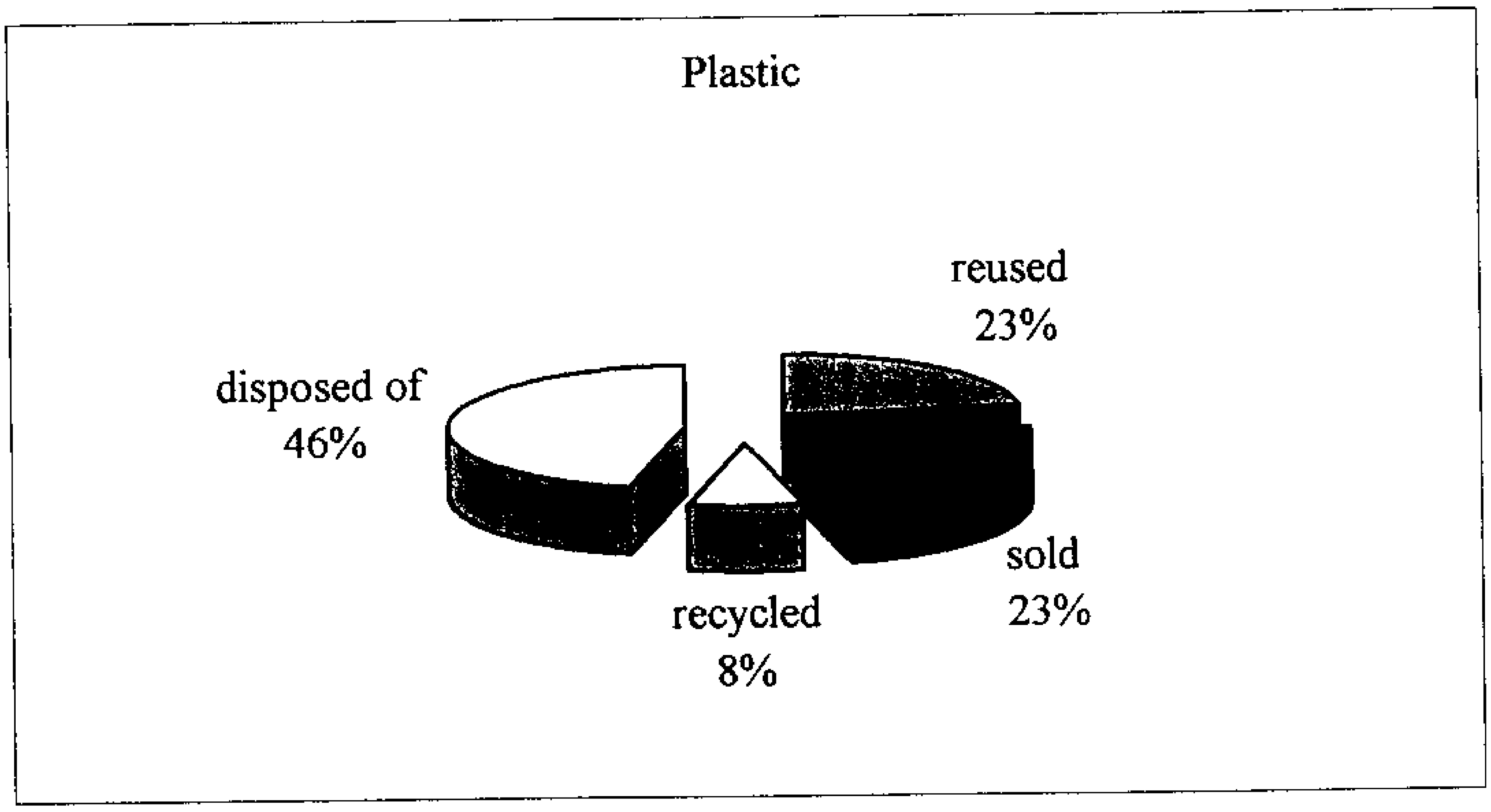

Figure 5: Handling of plastic wastes.

Almost 50% of the industries throw their paper waste with domestic waste, while 20% are reused and the same percentage is sent for recycling.
Concerning plastic waste, about 8 % is recycled. We must point however that recycling facilities for plastic waste are not available in Lebanon, and this figure shows the recycling of off specs products in the process of some industries.

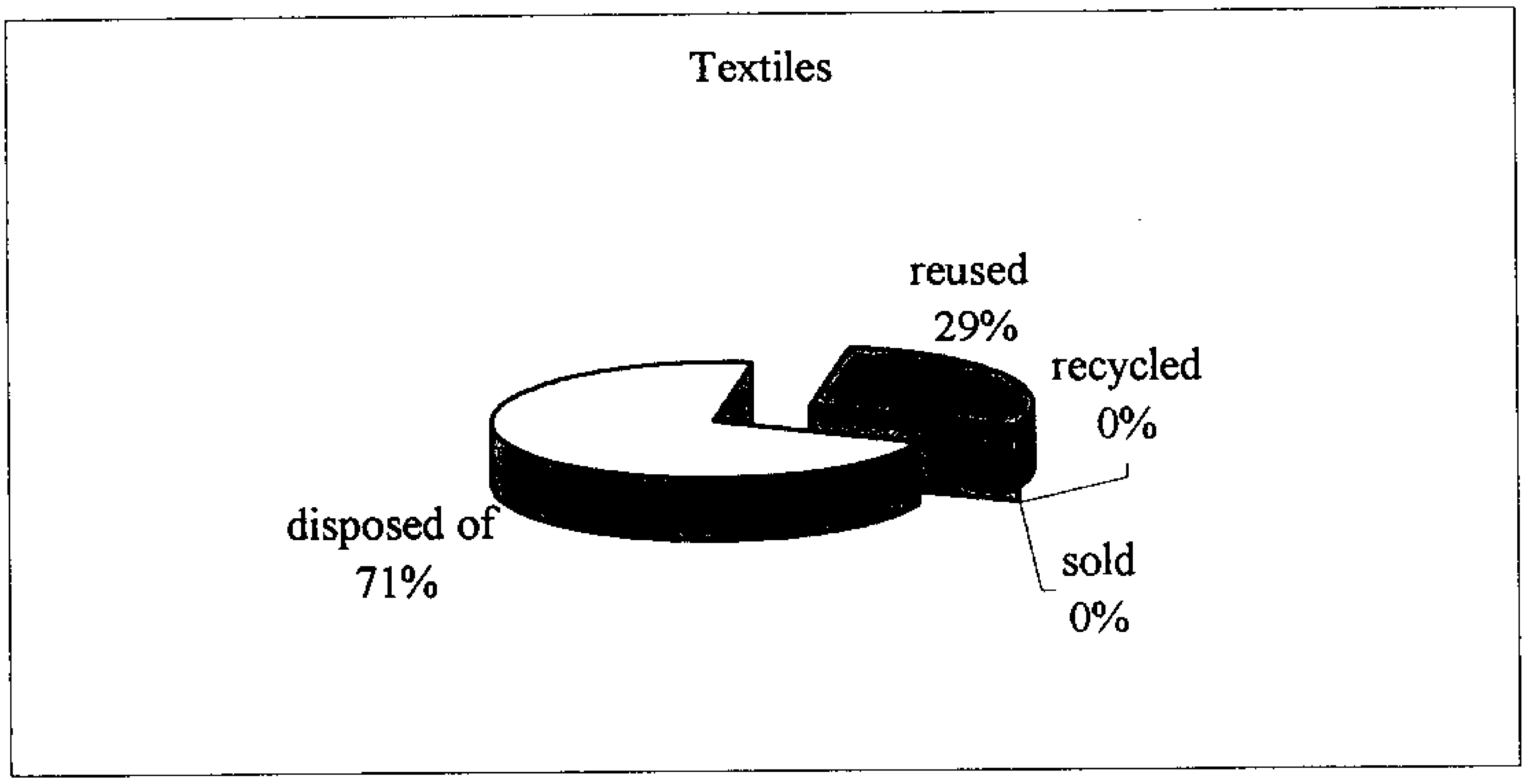

Figure 6: Handling of textiles wastes.

The recycling possibilities of textile are very narrow. 71% of this kind of waste is being disposed of, while 29 % are being reused for cleaning in most of the cases.

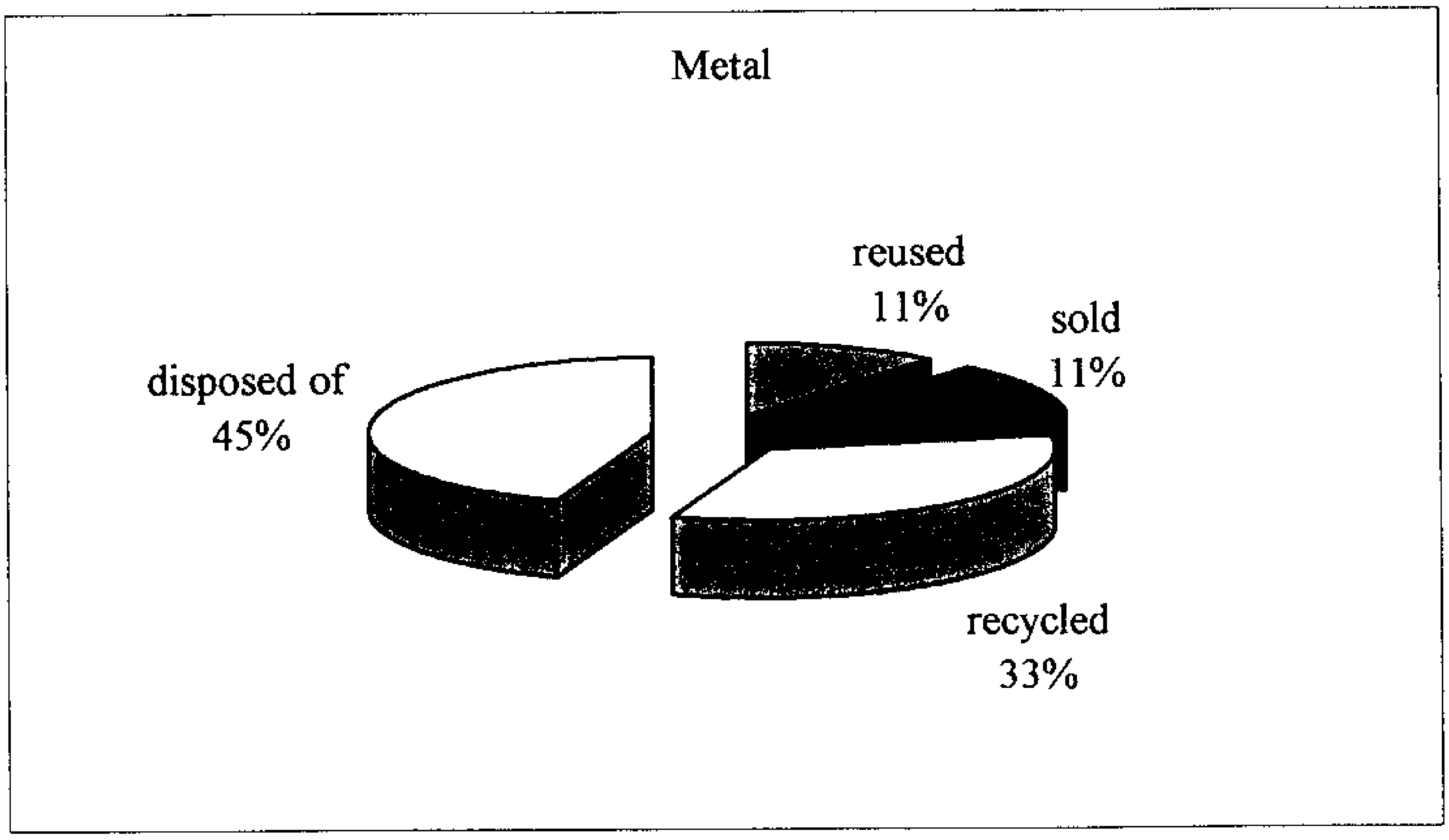

Figure 7: Handling of metal wastes.

33% of the metal waste generated is recycled. This concerns mainly the aluminum sector where leftovers pieces are sent again for melting and extrusion. However, a large percentage (45%) of metal is disposed of with domestic waste, while 11 % is being sold as scrap.

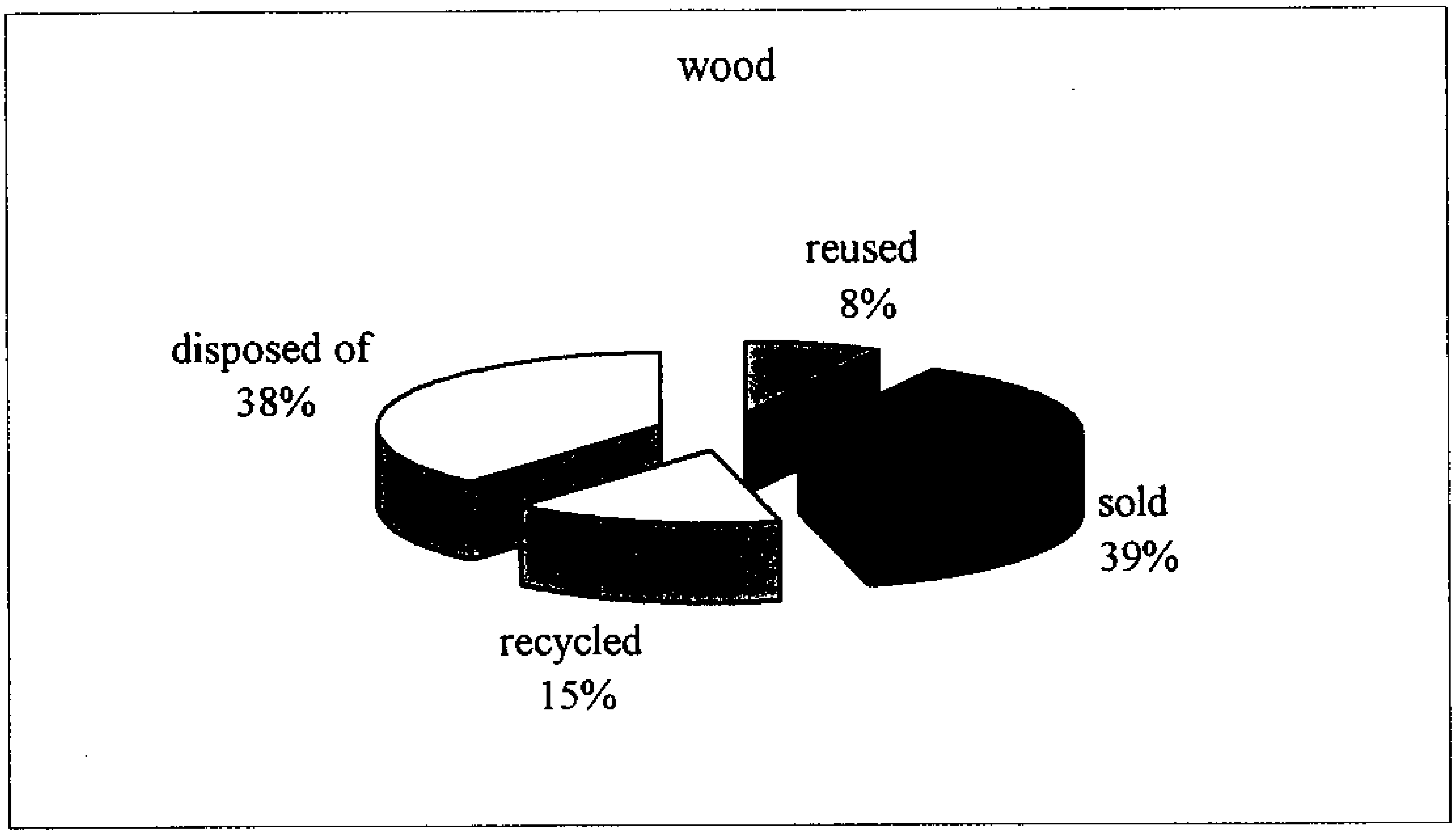

Figure 8: Handling of wood wastes.

Wood is mainly constituted by pallets and by scrap leftovers in the furniture industry, disposed of with domestic waste.

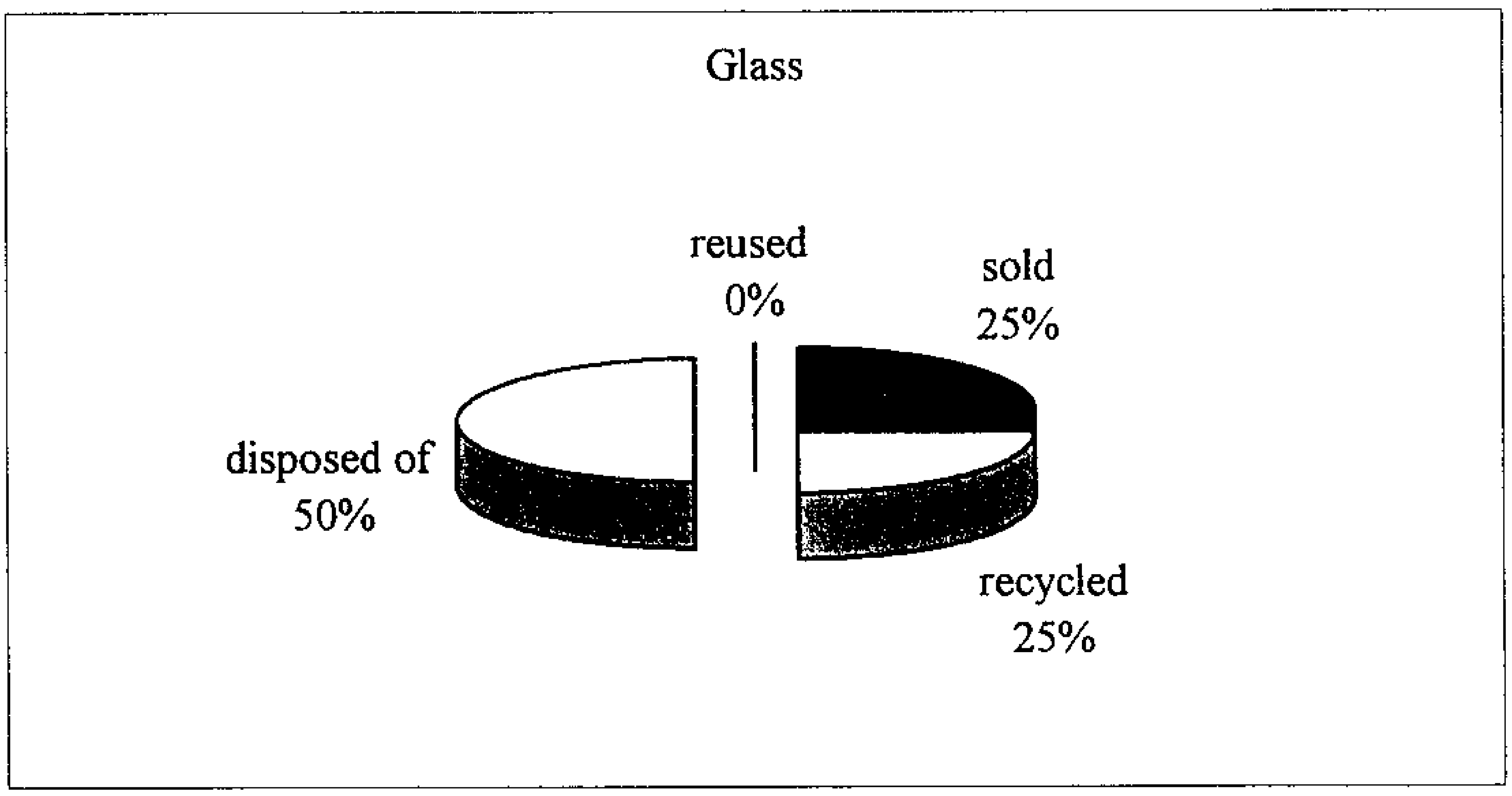

Figure 9: Handling of glass wastes.

Recycling possibilities of glass are very limited in Lebanon. Most of the generated glass waste (50%) is being disposed of with domestic waste. Almost 25 % of glass is being recycled off site (melt and reused again).

4. WASTEWATER GENERATION

Almost half of the industries visited discharge their effluents in the public channel that flows directly into the sea. Only 18% gave figures concerning the wastewater they generate per year (see Table 2).

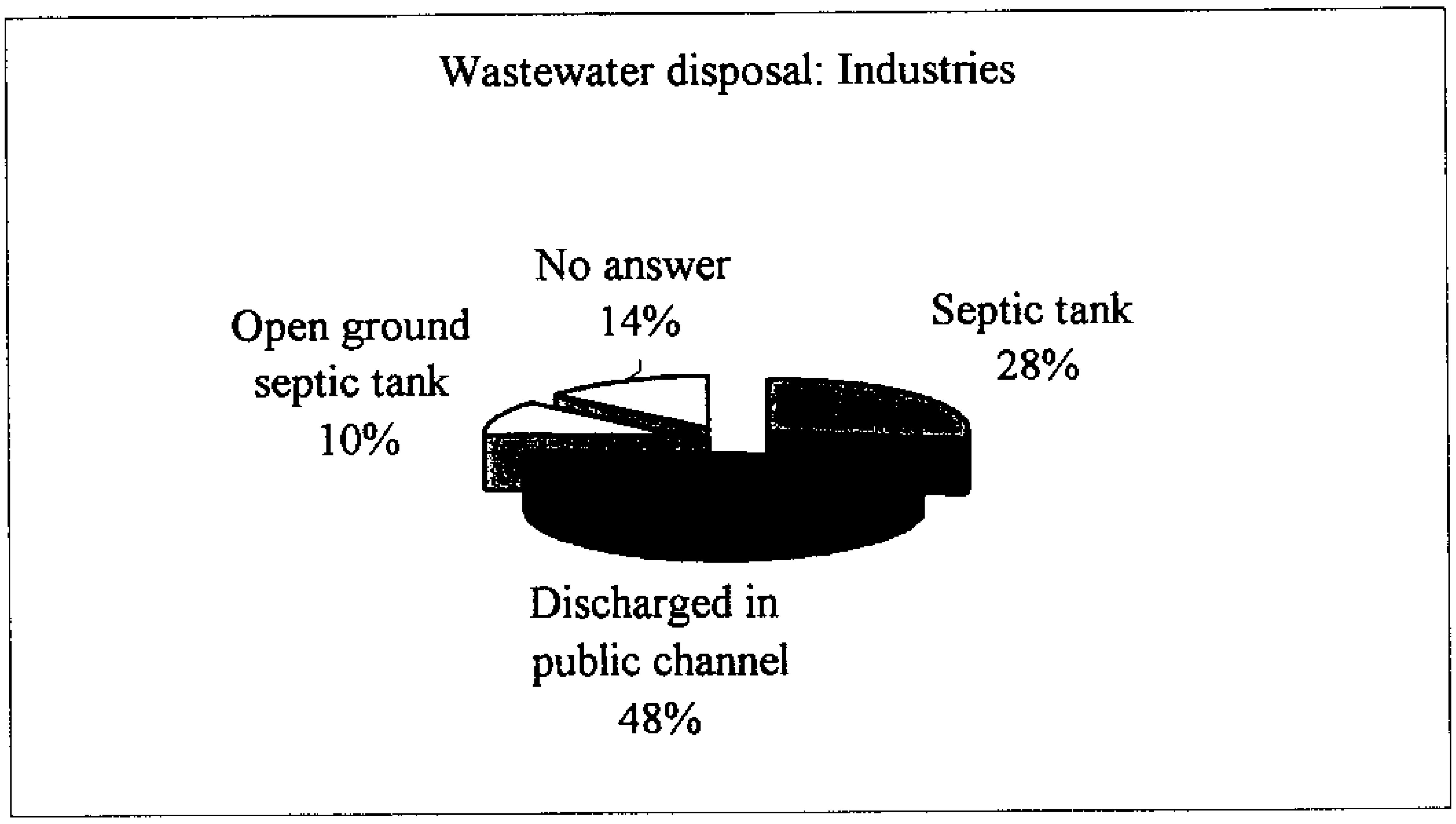

Figure 10: Wastewater disposal of visited industries.

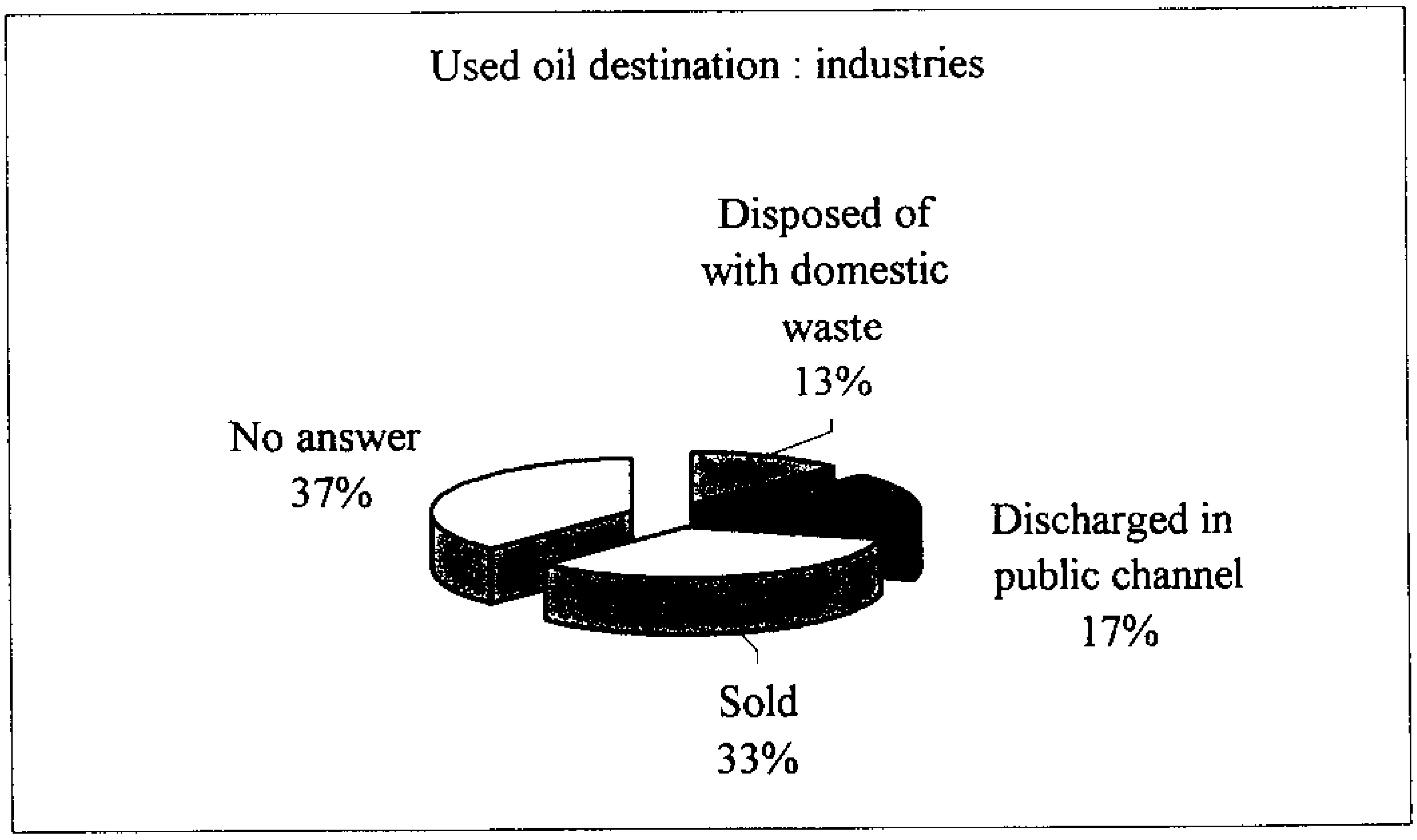

Figure 11: Used oil destination (Industries).

About 20 % of the interviewed repair and paint shops admit discharging their effluents (mainly oil, paints, thinner) in the public channel. 62% sell the oil generated by their activities to third parties.
About 66 % of the interviewed establishments were reluctant on answering where do they discharge their paint and thinner effluents. But most probably those effluents are being released in the open public channel.

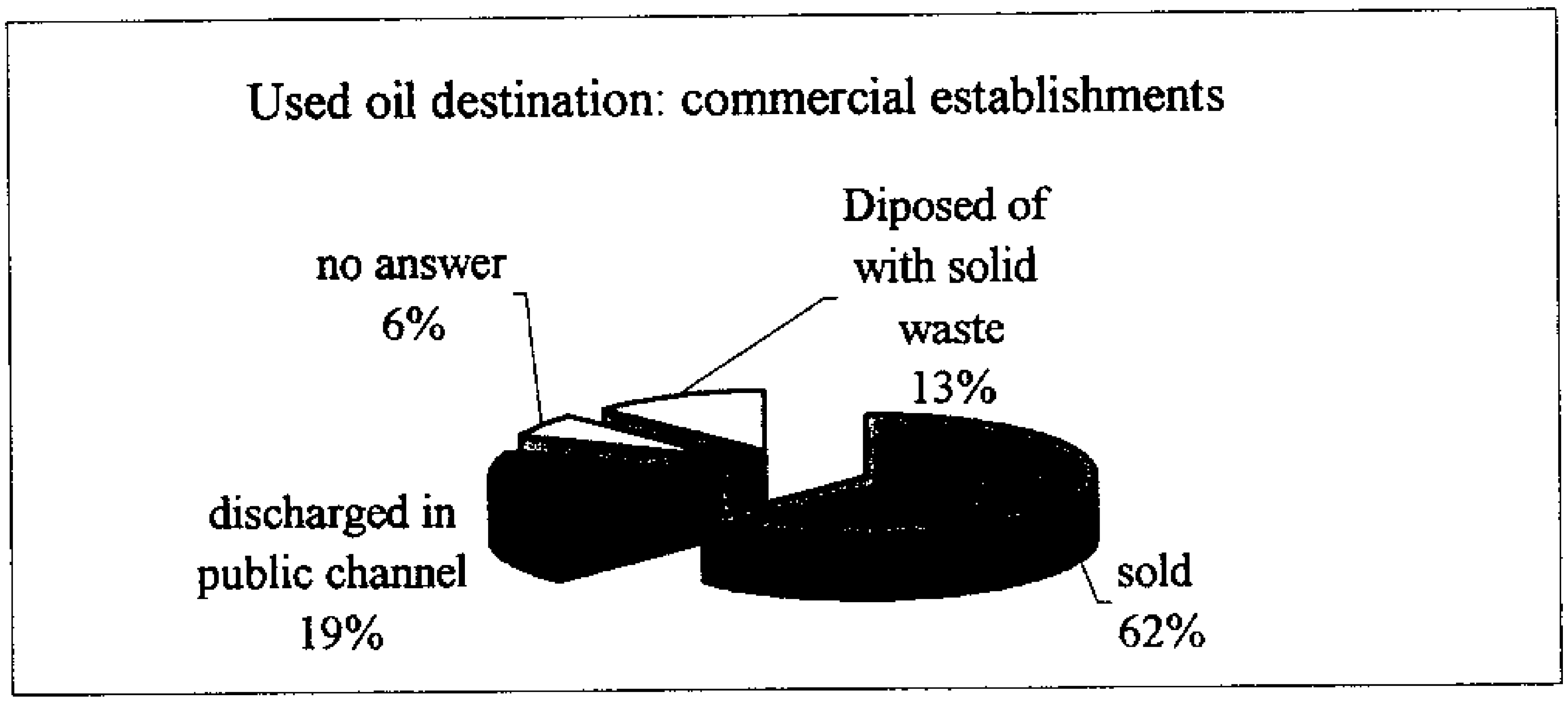

Figure 12: Used oil destination (Commercial establishments).

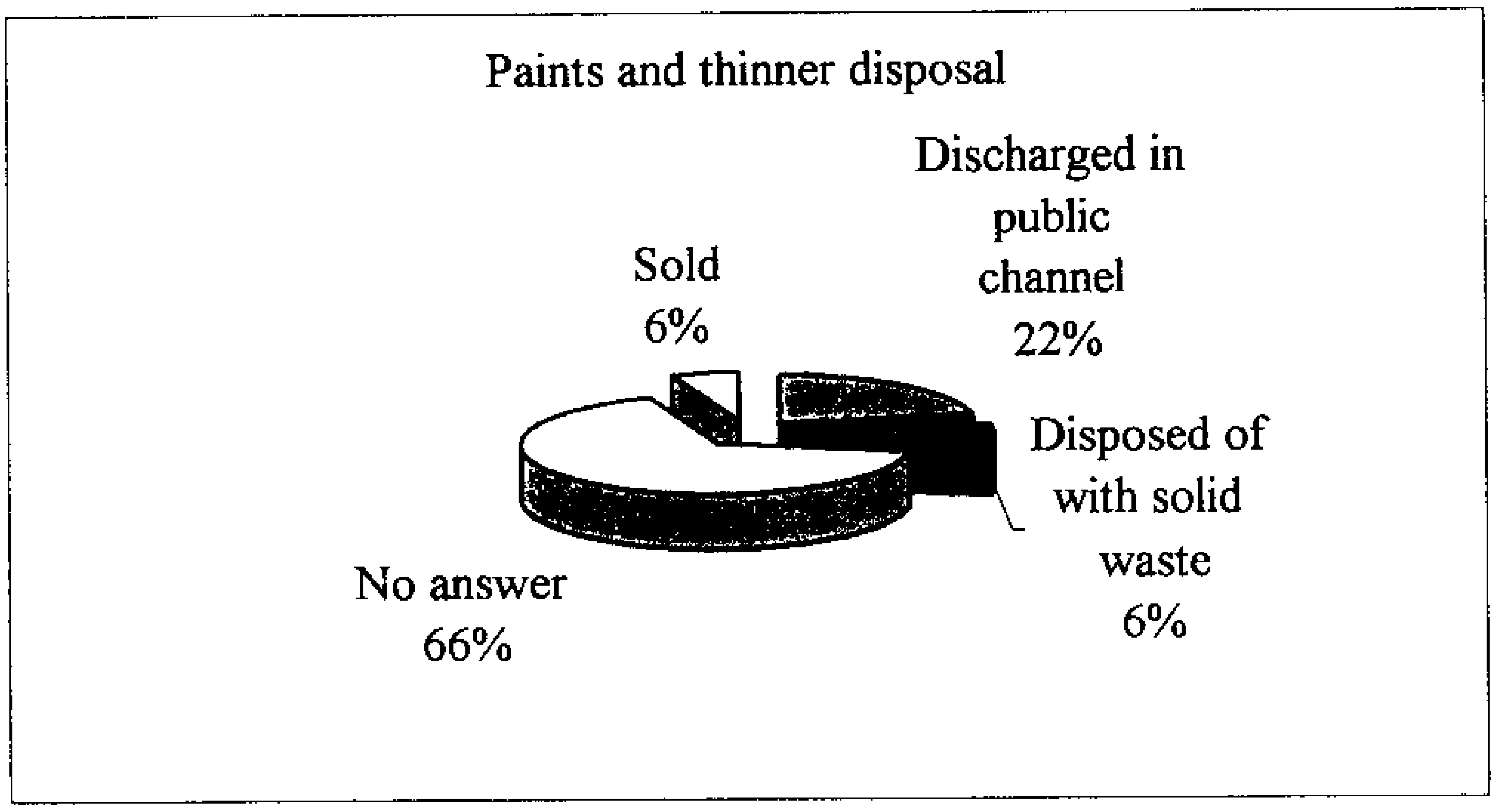

Figure 13: Paints and thinner disposal.

Since there was no reliable information concerning the quantities of wastewater and solid waste generated by the commercial establishments, it was not possible to make a serious comparison with wastes originated from the industries and thus to make a pertinent evaluation of the sources of waste. Some of the commercial establishments interviewed gave ridiculous figures of 2 – 3 kg of used oil generated by month while others estimated the same kind of waste to be as high as 500 kg. No relevant estimation could be made in this case. It is to note in addition that some of the oil stations visited refused even to welcome our delegates.

5. AIR EMISSIONS

In General, there are 4 types of estimation techniques that can be used to estimate air emissions of a facility:

- Sampling or direct measurement.
- Mass balance.
- Fuel analysis or other engineering calculations, and
- Emission factors.

Considering that no national emission factors have been obtained, it has become an accepted practice to adopt emission factors from other sources (such as USEPA, UNEP or national authorities in other countries) to reach a relatively reliable approach to the estimation of industrial air emissions in normal operation.

5.1 Power generation

Zouk Mosbeh power plant consumes an average of 900,000 tons of fuel oil per year. The combustion of heavy fuel oils is an important source of emissions to air of different types of pollutants.

Filterable particulate matter (PM) emissions depend on the completeness of combustion as well as on the oil ash content. The PM emitted by distillate oil-fired power generators primarily comprises carbonaceous particles resulting from incomplete combustion of oil and is not correlated to the ash or sulfur content of the oil. However, PM emissions from residual oil burning are related to the oil sulfur content. This is because low-sulfur No. 6 oil, either from naturally low-sulfur crude oil or desulfurized by one of several processes, exhibits substantially lower viscosity and reduced asphaltene, ash, and sulfur contents, which results in better atomization and more complete combustion.

Sulfur oxides (SO_x) emissions are generated during oil combustion from the oxidation of sulfur contained in the fuel. The emissions of SO_x from conventional combustion systems are predominantly in the form of SO_2. Uncontrolled SO_x emissions are almost entirely dependent on the sulfur content of the fuel. On average, more than 95% of the fuel sulfur is converted to SO_2, about 1 to 5 percent is further oxidized to sulfur trioxide (SO_3), and 1 to 3% is emitted as sulfate particulate. SO_3 readily reacts with water vapor (both in the atmosphere and in flue gases) to form a sulfuric acid mist.

Oxides of nitrogen (NO_x) formed in combustion processes are due either to thermal fixation of atmospheric nitrogen in the combustion air ("thermal NO_x"), or to the conversion of chemically bound nitrogen in the fuel ("fuel NO_x"). The term NO_x refers to the composite of nitric oxide (NO) and nitrogen dioxide (NO_2). Test data have shown that for most external fossil fuel combustion systems, over 95% of the emitted NO_x is in the form of nitric oxide (NO). Nitrous oxide (N_2O) is not included in NO_x but has recently received increased interest because of atmospheric effects.

The rate of carbon monoxide (CO) emissions from combustion sources depends on the oxidation efficiency of the fuel. By controlling the combustion process carefully, CO emissions can be minimized. Thus if a unit is operated improperly or not well maintained, the resulting concentrations of CO (as well as organic compounds) may increase by several orders of magnitude. The presence of CO in the exhaust gases of combustion systems results principally from incomplete fuel combustion.

The releases of the mentioned pollutants from the Zouk Mosbeh power plant can be estimated using the emission factors suggested by the USEPA, giving the following results:

Consumption (ton/year)	Pollutant released	Emission Factor (kg/ton fuel)	Releases (kg pollut./year)
900000	SO_2	18.84 x S*	33,912,000
	SO_3	0.68 x S*	1,224,000
	NO_x	5.64	5,076,000
	CO	0.6	540,000
	Filterable PM	2.59*	2,331,000

Table 3: Estimated air emission from Zouk Mosbeh power plant.
* S is the sulfur content originally found in the fuel oil burned. For this estimation, a value of 2% was adopted.

Small amounts of organic compounds are emitted from combustion. As with CO emissions, the rate at which organic compounds are emitted depends, to some extent, on the combustion efficiency. Therefore, any combustion modification which reduces the combustion efficiency will most likely increase the concentrations of organic compounds in the flue gases. Total organic compounds (TOCs) include VOCs, semi-volatile organic compounds, and condensable organic compounds. Emissions of VOCs are primarily characterized by the criteria pollutant class of unburned vapor phase hydrocarbons. Unburned hydrocarbon emissions can include essentially all vapor phase organic compounds emitted from a combustion source. These are primarily missions of aliphatic, oxygenated, and low molecular weight aromatic compounds which exist in the vapor phase at flue gas temperatures. These emissions include all alkanes, alkenes, aldehydes, carboxylic acids, and substituted benzenes (e. g., benzene, toluene, xylene, and ethyl benzene).

The remaining organic emissions are composed largely of compounds emitted from combustion sources in a condensed phase. These compounds can almost exclusively be classed into a group known as polycyclic organic matter (POM), and a subset of compounds called Polynuclear Aromatic Hydrocarbons (PAH or PNA).

Organic pollutants and trace heavy metals released from Zouk power plant may be estimated using the emission factors suggested by UNEP, giving the following releases per year:

Consumption (Ton/year)	Pollutant released	Emission Factor (kg/ton fuel)	Releases (kg pollut./year)
900000	Benzene	2.5E-05	22.5
	Benzanthracene	4.8E-07	0.4
	Fluoranthene	5.4E-07	0.5
	Phenanthrene	1.3E-06	1.2
	Toluene	7.4E-04	666.0
	Benzo(b,k)fluoranthene	1.8E-07	0.2
	Benzo(g,h,I)perylene	2.6E-07	0.2
	Indeno(1,2,3-cd)pyrene	2.6E-07	0.2
	PAH (10 PAH)	4.4E-04	396.0
	Cd	4.7E-05	42.3
	Cr(VI)	3.0E-05	27.0
	F	4.5E-03	4050.0
	Ni	1.0E-02	9000.0
	Cr	1.0E-04	90.0
	Cu	2.1E-04	189.0
	Hg	1.4E-05	12.6

Table 4: Organic pollutants and heavy metals releases of Zouk Mosbeh power plant.

5.2 Textile dyeing processes.

Emissions to air can result from the printing and dyeing of fabrics, mainly consisting of volatile organic compounds (VOC). An estimation of the VOCs released for the visited textile dyeing facilities in Zouk Mosbeh can be obtained using the USEPA emission factor:

Facility	Production (ton fabric/year)	Emission Factor (kg/ton fabric)	VOC (kg pollut./year)
Filitex	450	2.3	1,035
Abdel Nour	8	2.3	18.4

Table 5: Estimation of air emission from textile dying process.

5.3 Dry cleaning.

The solvent itself is the primary emission from dry cleaning operations. Solvent is given off by washer, dryer, solvent still, muck cooker, still residue and filter muck storage areas. Premises using petroleum solvents usually do not employ solvent recovery devices due to the low cost of the solvents. Solvent recovery is necessary in perc plants due to the higher cost of perchloroethylene; recovery is performed through the use of condensers, water/solvent separators and carbon adsorption units. Residual solvent emitted from treated distillation bottoms and muck is not recovered.

For premises using perchloroethylene (transfer process), it is estimated that a solvent loss of 8 kg/l00kg of clothes cleaned is emitted to air. For those using petroleum solvents in the transfer process, a solvent loss of 18 kg/100 kg of clothes cleaned is estimated.

All fluorocarbon machines are of the dry-to-dry variety to conserve solvent vapor, and all are closed systems with built in solvent recovery. Emissions are almost negligible unless poor maintenance and operation of equipment.

An estimation for the volatile organic compounds (VOC) released from dry cleaning operations can be obtained using the USEPA emission factors for a typical system:

Facility	Production (Ton clothes/year)	Emission Factor (kg VOC/ton clothes)	VOC (kg pollut. /year)
La Primera	24*	80	1,920
Abdel Massih	Not disclosed	80	NA

Table 6: Estimated air emissions from dry cleaning operations.

* This is the total production of the facility, including dyeing and dry cleaning. Due to lack of details, the total production was adopted for this estimation; therefore, a lower load of VOC can be expected.

5.4 Powdered detergents production.

The exhaust air from detergent spray drying towers contains mainly fine detergent particulates. Dust emissions are generated scale hoppers, mixers and crutchers during batching and mixing of dry ingredients from slurry as well as from conveying and packaging. Dry cyclones are usually used to reduce emissions and recover raw materials.

For premises having cyclone controls for particulate emissions, it is estimated that a total of 7kg of particulates per ton of products are released.

Using the USEPA emission factors, the following estimation for particulate matter releases can be obtained:

Facility	Production (ton /year)	Emission Factor (kg PM/ton)	PM (kg pollut./year)
Henkel	18000	7*	126,000
Scte. Libano Italienne	2500	7*	17,000

Table 7: Estimated air emissions from powder detergent production.
*Emission factor for a process having a cyclone for dust control.

5.5 Electroplating and anodizing.

Chromium baths in the aluminum electroplating industries release metal-ion bearing mists, that is, small metal ions trapped in vapor molecules evaporating from the baths. The releases are directly related to the amount of energy passed through the bath and its area. An emission factor of 7.77 mg/A-hr (mg of chromium compounds per Ampere per hour) is reported in the National Pollutant Inventory (Australia). The amount of current for chromium anodizing usually ranges between 1,550 to 7,750 A/m^2.

Data of the area of the anodizing bath as well as the anodization time is not available for Sidem facility, having a total production of 13,000 tons/year.

No emission factors are reported for the silver-plating baths, which consist traditionally of a cyanide-based, plating solution.

5.6 Paper production.

The paper production implies the consumption of large quantities of steam for pulp drying. Steam generation in boilers is an important source of carbon and nitrogen oxides; the drying of paper pulp also releases volatile organic compounds.

According to the emission factors set by the National Pollutant Inventory (Australia), the following estimation can be made for air emissions from the paper production facility visited at Zouk Mosbeh (Ninex):

Production (ton/year)	Pollutant released	Emission Factor (kg/ton fuel)	Releases (kg pollut./year)
1100	CO	5E-05	0.055
	NO_x	2.5E-04	0.275
	VOC	5E-06	0.0055
	Particulate matter (PM)	84	92,400

Table 8: Estimated air emissions from paper production.
*Emission factor for drying pulp with a recovery boiler with a direct-contact evaporator and an ESP

5.7 Wood furniture finishing

Wood furniture finishing implies the use of many solvents such as acetone and ammonia to pre-treat the surface before coating, which may result in releases to air according to the National Pollutant Inventory.

Many of finishing applications (such as coating) use relatively high concentrations of VOCs which volatilize when the coating is applied.

The consumption of solvents and coatings by the wood finishing facilities visited at Zouk (Sahaco and Many Doro) was not disclosed.

5.8 Vegetable oils refining

The most common method for oil refining is by reacting it with alkali to neutralize free fatty acids and remove phosphatides. These reacted products and the proteinaceous materials are then removed by centrifugation.

Oil is washed with water to remove excess of alkali. Then, it is deodorized by using steam injection under high vacuum and temperatures. This operation is the source of the release of annoying odors that can be perceived in the surroundings.

6. Interpretation of wastewater analysis results

Analysis of wastewater results is presented for every pollutant. The general table in the annex section shows the wastewater results in comparison with national Environmental Limit Values (ELV).

6.1 pH

The pH values of 79.6 % of the industries sampled fall within the ELV's limits, ranging between 5 and 9. It concerns notably the following industries: Filitex, Henkel, La Primera, Abdel Massih (Tag sarl), Sidem, Azar Karam, Hcheimy, Adams Warner-Lambert, Colortex, Ninex, and Société Libano-Italienne.

However, pH levels at Habis (9.45 and 11.34 on the first and second stage of sampling respectively) and ZM Vegetable oil (9.88) show a high alkalinity due to the use of alkaline compounds in the process, such as NaOH used in the electrochemical bath by Habis and for the neutralization by ZM Vegetable oil. It is to note though that the baths at Habis are discharged every four months in septic tank with an unlined bottom.

Facility	pH ELV = 5-9		
	1st stage of sampling	2nd stage of sampling	3rd stage of sampling
Intersection	11.68	9.45	12.31
Habis	9.45	11.34	-
ZM Vegetable oil	9.88	9.88	-

Table 9: pH values outside ELV.

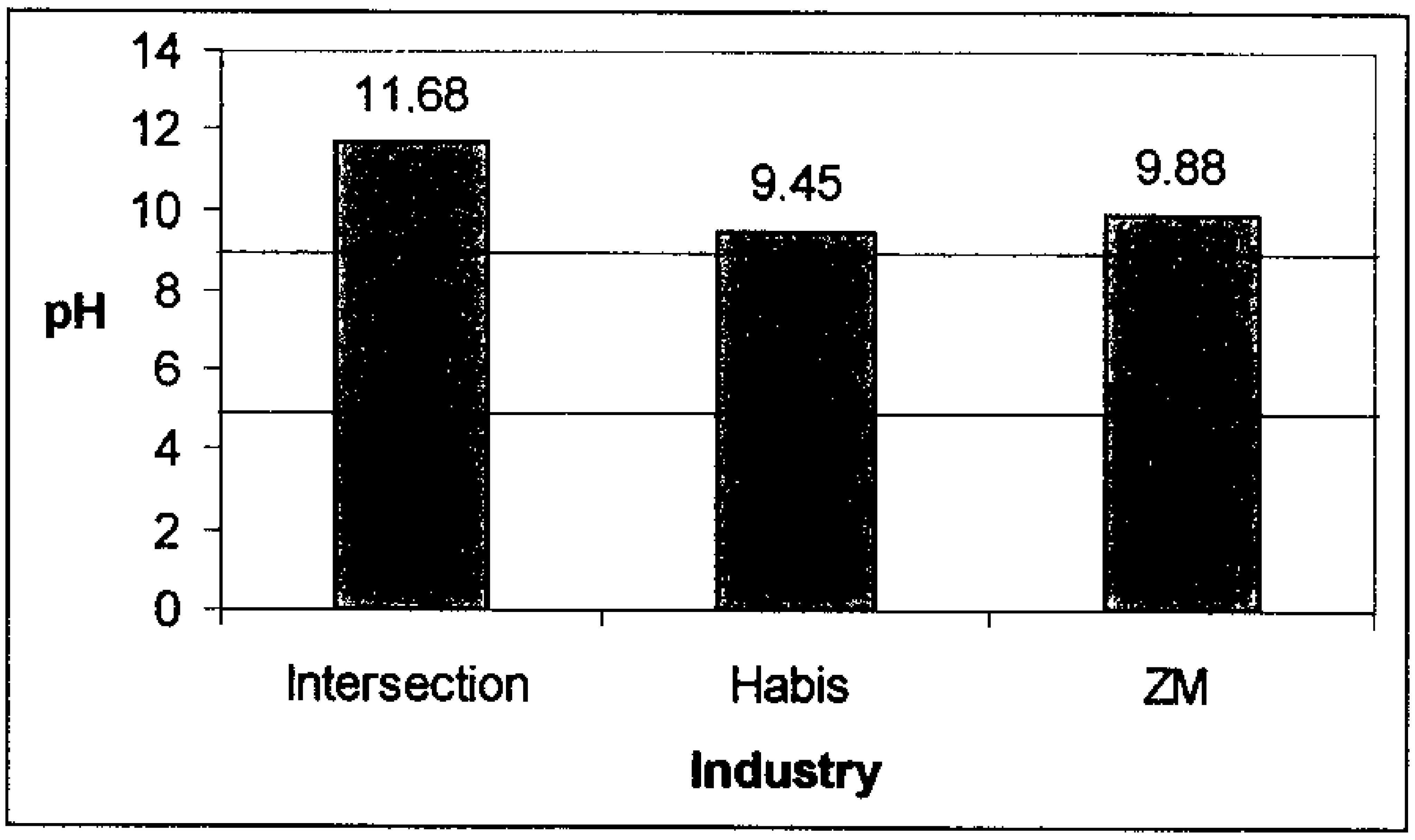

Figure 14: pH values outside ELV.

BOD


الجمهورية اللبنانية
مكتب وزير الدولة لشؤون التنمية الإدارية
مركز مشاريع ودراسات القطاع العام
N
Accepted Level
Levels Above National ELV's
Intersection Channel
Sampling Sites
Industrial Zone
Zouk Mosbeh
50
0
50
Meters

On the other hand, concerning the intersection channel, where effluents coming out from Colortex, Henkel, Hcheimy, and Filitex meet, high pH values were detected during three stages of sampling. It is interesting to note that the pH measurements of the water collected from the intersection channel exhibited higher values than those measured for each of the effluents that are discharged into it. It was obvious then that an alkaline solution coming from another source is being discharged at irregular time into the channel. The source of this alkaline solution could not be determined.

6.2 Biological Oxygen Demand (BOD)

About 57% of the industries sampled showed levels of BOD above national ELV's. Samples were taken during two stages from Henkel, (213 mg/L and 267 mg/L), Société Libano- Italienne (stable at 124mg/L and 121 mg/L), and ZM Vegetable oil (4752 mg/L and 3720 mg/L). This latter facility showed very high levels of BOD with figures about 48 times and 37 times above the national ELV's (100mg/L). Filitex, Abdel Massih and La Primera showed close ranges of BOD values respectively 203, 250 and 195mg/L.

Concerning Colortex, it is to note that samples were taken from the channel outlet of the plant before dyeing and printing effluents were discharged. BOD levels are expected to be much higher in the channel after discharge. (BOD levels at dyeing and printing baths are respectively 266.4 mg/L and 127.5 mg/L). The same comment is valid for Ninex facility where BOD levels in the municipality channel are expected to rise after effluents generated from the washing machine bath will be released. (BOD levels at Ninex washing machine: 151.3 mg/L).

Concerning the intersection channel, high levels of BOD were detected (177 mg/L, 255.3mg/L and 267.9 mg/L, respectively) during three stages of sampling.

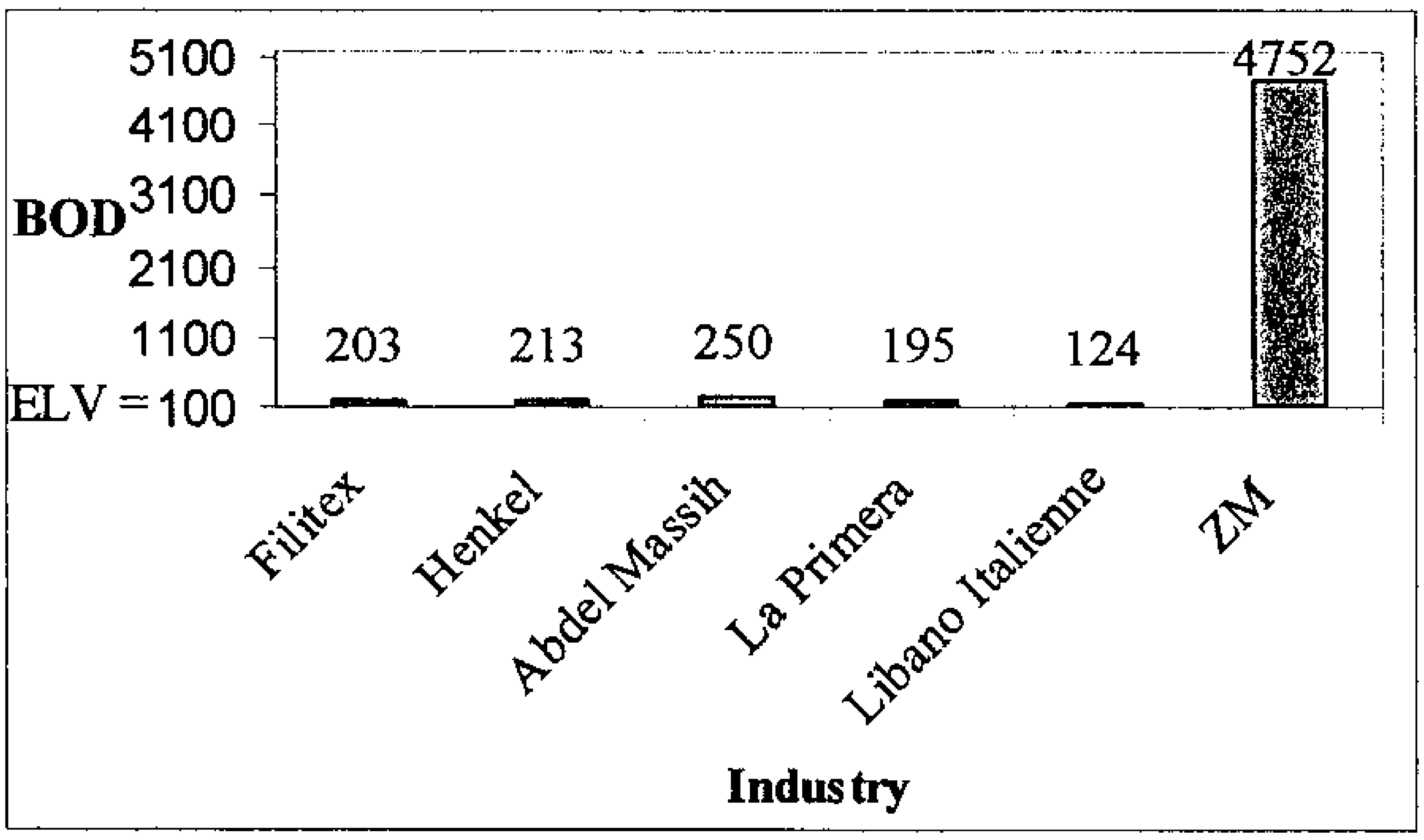

Figure 15: BOD values outside ELV.

6.3 Chemical Oxygen Demand (COD)

Very high levels of COD were observed in 64% of the effluents analyzed. Nearly 50% of which have COD levels above 1000 mg/L and 30% have levels above 2000mg/L. One facility (ZM Vegetable oil) reached a figure of 34 200 mg/L (almost 137 times the national ELV).

Facility	COD (mg/L) ELV = 250mg/L			BOD (mg/L) ELV = 100mg/L		
	1st stage of sampling	2nd stage of sampling	3rd stage of sampling	1st stage of sampling	2nd stage of sampling	3rd stage of sampling
Filitex	627	-	-	203	-	-
Henkel	1682	5060	-	213	267	-
Intersection		1995	3542	177	255.3	267.9
AbdelMassih	779	-	-	250	-	-
La Primera	2547	-	-	195	-	-
Adams	1331	-	-	-	-	-
LibanoItalienne	-	-	-	124	121	-
ZM	34200	9816	-	4752	3720	-
Colortex	-	1113	-	68*	-	-
Ninex	809.6	-	-	73.4*	-	-
Algorithm	-	342	-	-	-	-

Table 10: BOD and COD values outside ELV.
* Sample taken from the channel before discharging effluents coming from washing machine

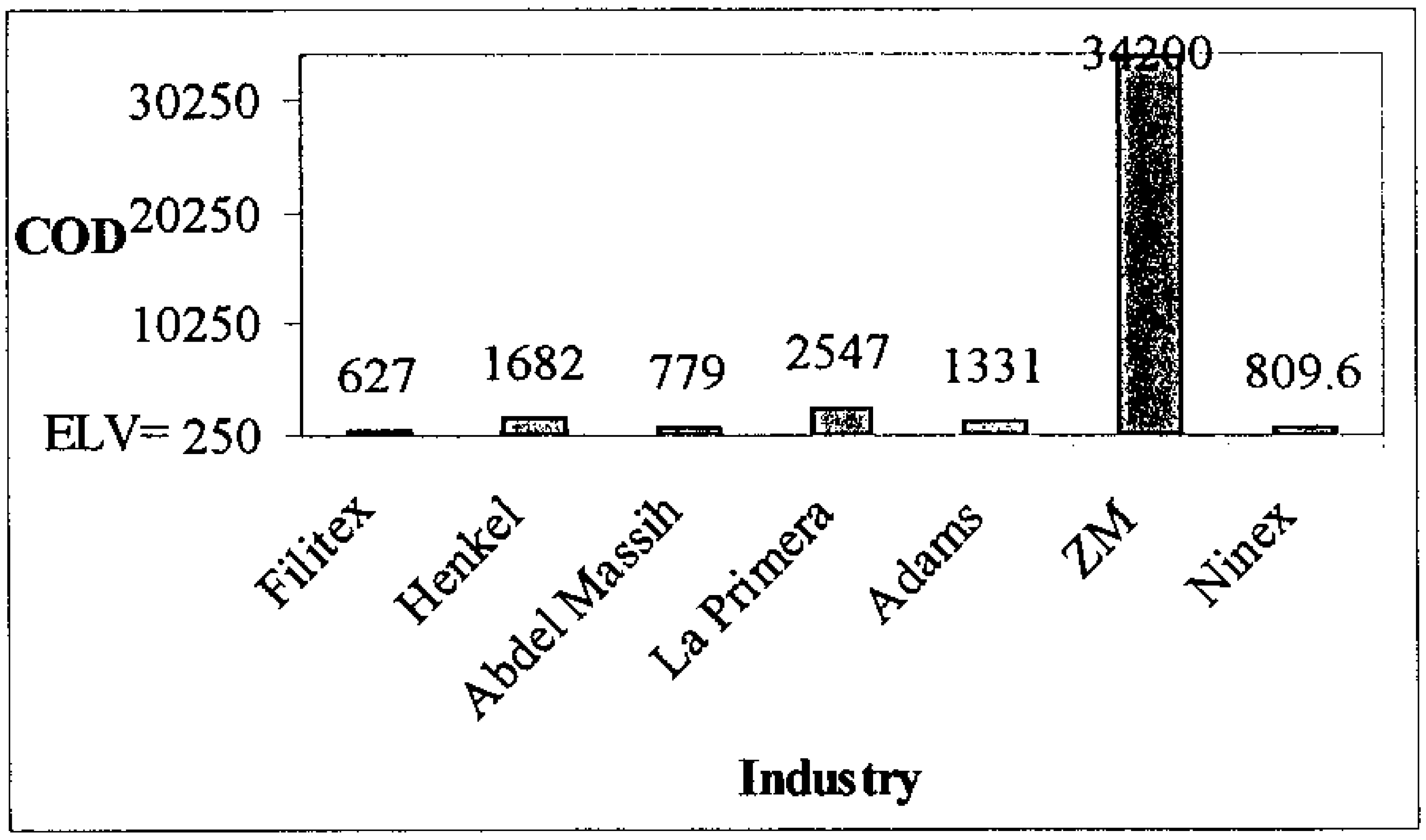

Figure 16: COD values outside ELV.

Concerning the channel intersection, three stages of sampling gave also figures high above national standards. (5 times, 14 times and 8 times the national ELV). It is to note that the BOD and COD levels are well correlated for the same facility and such high values normally point to organic pollution in the water.

6.4 Total Suspended Solids (TSS)

Suspended solids are present in high quantities in 43 % of the sampled industries. They are mainly concentrated:

- In the dry-cleaning factories, (La Primera 262 mg/L, and Abdel Massih 332 mg/L and 9694mg/L in the bleaching water tank) mainly due to the use of dyeing and bleaching agents;
- In the detergent facilities (Société Libano-Italienne 290 mg/L); the marble factories (Hcheimy 230 mg/L, marble powder suspended in water);
- In the aluminum extrusion and coating facility (Sidem 750 mg/L, washing products after rinsing bathing),
- In the oil treatment facility (ZM Vegetable oil, suspended oil particles). In this latter facility, levels of TSS were respectively found as high as almost 26 and 66 times above the national ELV (200mg/L) during the first and the second stage of sampling.

It is to note that in Abdel Massih factory, the sample was taken from the channel inside the factory before discharging the bleaching solution. Levels of TSS are expected to rise significantly in the channel after emptying the bleaching tanks. (TSS 9694 mg/L in bleaching tanks).

Facility	TSS (mg/L) ELV = 200 mg/L		
	1st stage of sampling	2nd stage of sampling	3rd stage of sampling
Abdel Massih 1	332	-	-
Abdel Massih 2	9694*	-	-
La Primera	262	-	-
Sidem	750	-	-
Libano Italienne	290	-	-
Hcheimy	230	-	-
ZM	5122	13270	-
Intersection	-	-	274

Table 11: TSS values outside ELV.

* The Abdel Massih 2 sample was taken from the bleaching water bath, before discharge to channel. The high concentration of TSS lead us to point that after discharging the bath into the channel, levels of TSS in the water flowing out into the channel (Abdel Massih 1) will be much higher.

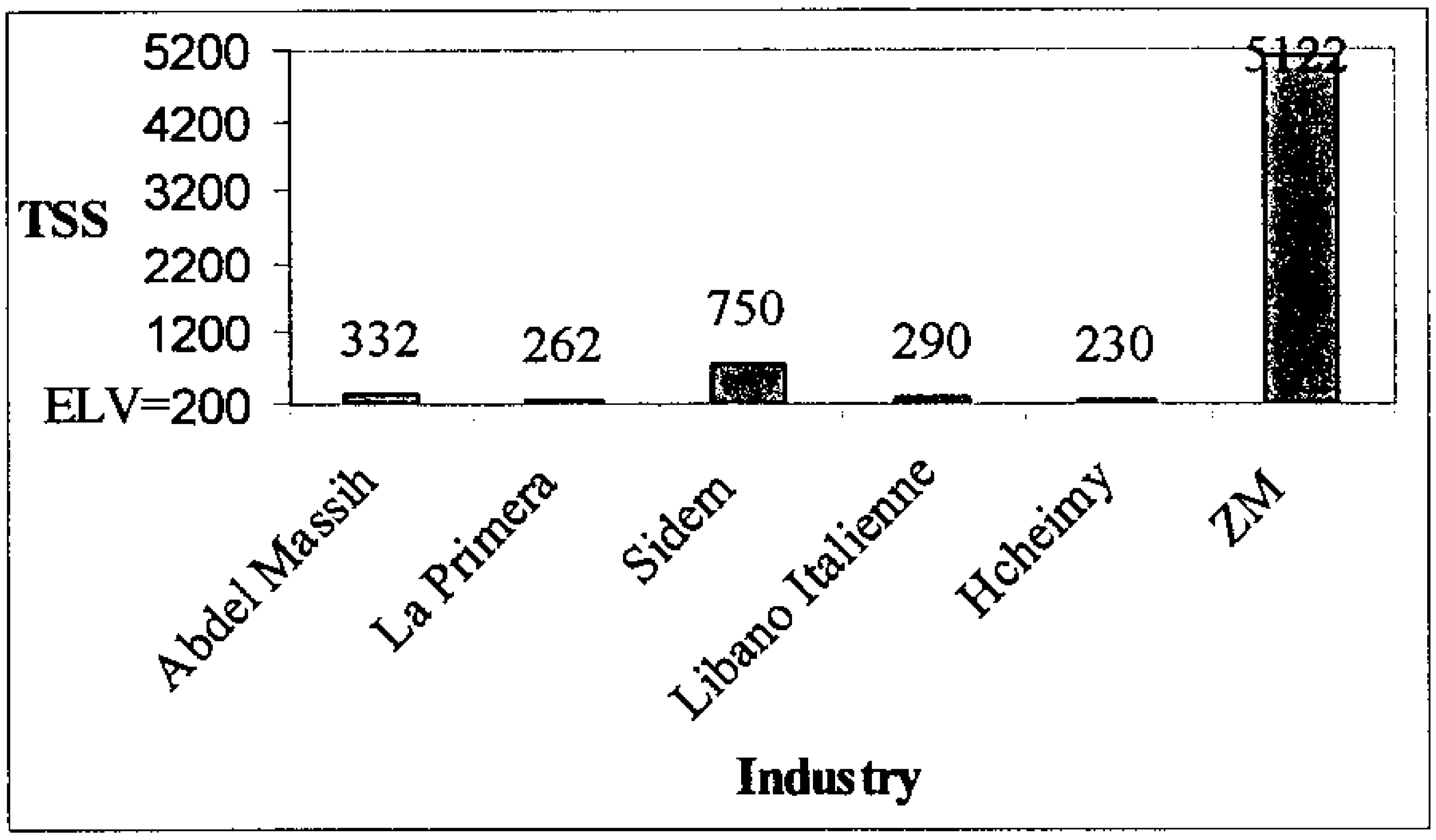

Figure 17: TSS values outside ELV.

6.5 Total kjeldahl N (TKN)

High levels of TKN were found in samples taken from ZM Vegetable oil facilities (76.8mg/L). TKN in all other industries fall within ELV's limits (40 mg/L).

6.6 Ammoniacal Nitrogen (NH_3-N)

High levels of ammonia were measured in samples taken from Colortex facility on the first stage (265mg/L) and second stage (11mg/L) of sampling. All other facilities fall within the ELV's limits (10mg/L).

6.7 Phosphorous

Levels of phosphorous were found above ELV's (16mg/L) in 28.6% of total sampled industries. The facilities are namely Henkel (103.1 mg/L), La Primera (136.1mg/L), ZM Vegetable oil (71 .7 mg/L and 44.2 mg/L during two stages of sampling), and Abdel Massih. Its source is mainly detergents and surface active agents used in this type of facilities.

Concerning Abdel Massih facility, the sample was taken from the channel inside the factory (Phosphorus level 3.1 mg/L, below ELV limits) prior to discharging the bleaching water (phosphorus level in bleaching water 35.4mg/L). Thus, concentrations of Phosphorus are expected to rise after bleaching water is released in the channel.

Phosphorous levels were found above ELV's at the intersection channel (18.2mg/L), however in an acceptable range.

Facility	Phosphorous P (mg/L) ELV = 16 mg/L		
	1st stage of sampling	2nd stage of sampling	3rd stage of sampling
Henkel	103.1	-	-
Abdel Massih 1	3.1	-	-
Abdel Massih 2	35.4*	-	-
La Primera	136.1	-	-
ZM	71.7	44.2	-
Intersection	-	-	18.2

Table 12: Phosphorous values outside ELV.

* Sample was taken from channel inside factory prior to discharging the bleaching water. Concentration of P is expected to be much higher after discharge.

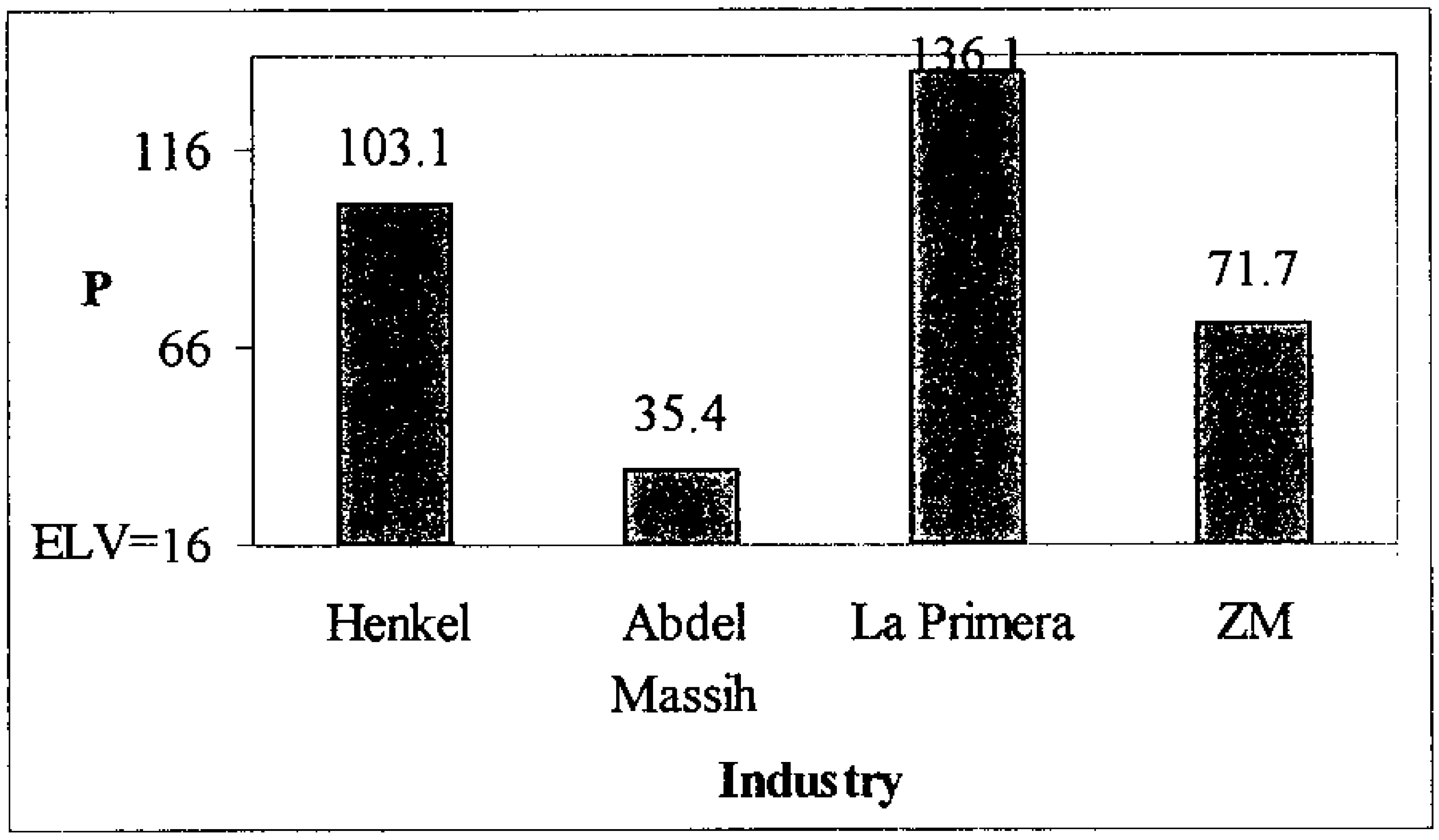

Figure 18: Phosphorous values outside ELV.

6.8 Oil and Grease

About 64% of the sampled industries have exceeded ELV limits (30mg/L) for Oil and Grease. The origin of Oil and Grease is mostly originated from the production (ZM Vegetable oil), from the raw materials used in the process (as antifoaming agents in Filitex), or from machine maintenance (Ninex).

On the other hand, the high levels measured at the intersection channel (483mg/L) can be related to the high levels of Oil and Grease found in Filitex (113mg/L) and Henkel (158mg/L) at the same time.

Total Suspended Solids

COD

N
Accepted Level
Levels Above National ELV's
Intersection Channel
Sampling Sites
Industrial Zone
Zouk Mosbeh
50
0
50
Meters

Oil & Grease

N
Accepted Level
Levels Above National ELV's
Intersection Channel
Sampling Sites
Industrial Zone
Zouk Mosbeh
50
0
50
Meters

Facility	Oil and Grease (mg/L) ELV = 30 mg/L		
	1st stage of sampling	2nd stage of sampling	3rd stage of sampling
Henkel	69	158	-
Intersection	313	483	123
Abdel Massih	208	-	-
La Primera	57	-	-
ZM	2034	71476	-
Algorithm	106	-	-
Ninex	1348	-	-
Sidem	-	696	-
Libano Italienne	167	-	-
Filitex	-	113	-

Table 13: Oil and Grease values outside ELV.

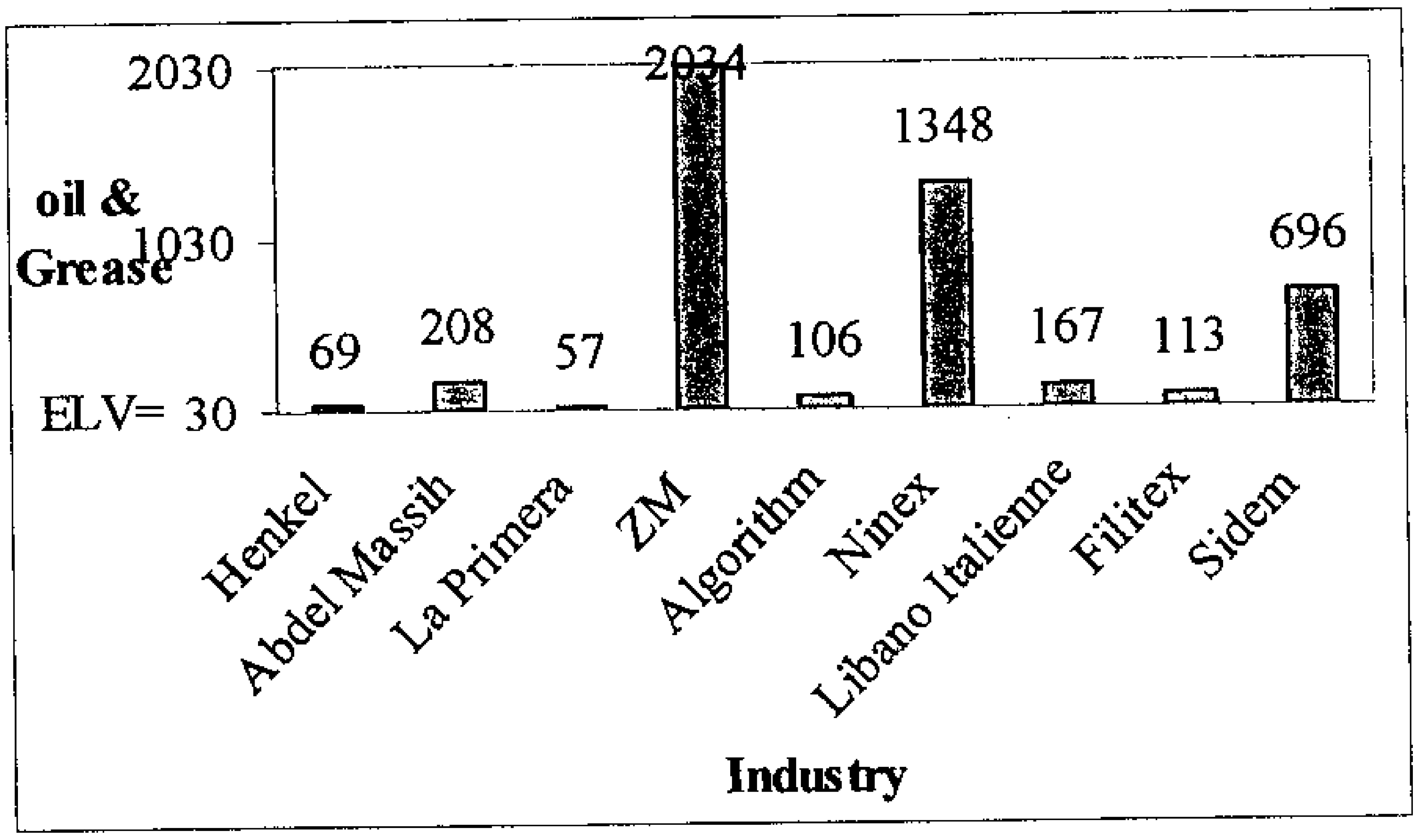

Figure 19: Oil and Grease values outside ELV.

6.9 Sulfides

The percentage of industries that have high levels of sulfides is about 28.57 %. It concerns mainly the dry cleaning factories, namely La Primera and Abdel Massih; one textile industry (Colortex 10.4 mg/L); and ZM Vegetable oil (260mg/L and 280 mg/L at two stages of sampling).

In addition, levels of sulfides in the channel inside the factory at Colortex are expected to be much higher after discharging the bleaching and printing baths (156mg/L).

Concerning Abdel Massih, levels of sulfides detected (5.6mg/L) are also expected to rise after bleaching baths (15.2mg/L) are discharged into the channel.

It is to note that at La Primera, the use of Metabisulfites raised the level of sulfides to 890 mg/L in the neutralization machine.
Finally at the intersection channel, levels of sulfides were found as high as 41.8 mg/L related to Colortex.

Facility	Sulfides (mg/L) ELV = 5 mg/L	
	1st stage of sampling	2nd stage of sampling
Intersection	41.8	-
Abdel Massih 1	5.6	-
Abdel Massih 2	15.2*	-
La Primera 1	8.9	-
La Primera 2	890*a	-
Colortex	10.4	156*b
ZM	260	280

Table 14: Sulfides values outside ELV.
* Sulfides are expected to be much higher after the bleaching bath is discharged into the channel
*a Concentrations of sulfides are much higher in La Primera 2 sample because of the use of metabisulfites
*b from washing and printing bath , concentrations are expected to be much higher after discharging into the channel

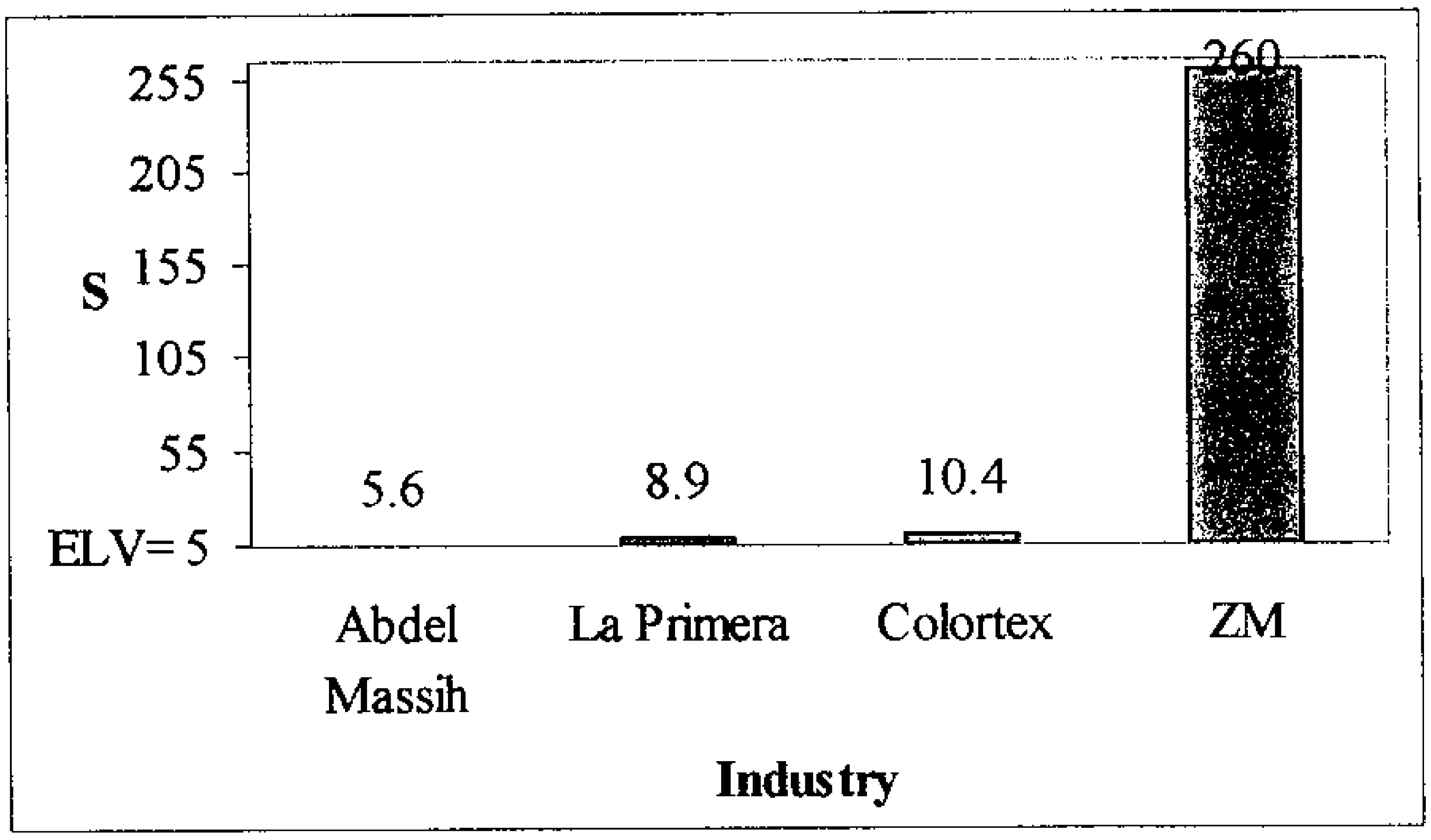

Figure 20: Sulfides values outside ELV.

6.10 Heavy Metals

The percentage of industries that have high levels of heavy metals is about 14.28 %. It concerns Cr III, Pb and Ag. Chromium III was detected in levels above ELV's at Sidem facility (3 mg/L), since chromium enters in the aluminum production during the chromating process (Chromium III ELV = 2mg/L). It is to note however that

Sidem facility is reducing the Chromium VI that is generated by the chromating process into Chromium III, which has less impact to health and environment than Chromium VI.
On the other hand, high levels of lead and silver were detected at Habis facility (3778 µg/L and 0.4 mg/L respectively, Lead Pb ELV = 500µg/L, Silver Ag ELV = 0.1 mg/L)
Heavy metals were not detected at the intersection channel.

6.11 Nitrates

Low level of nitrates was detected at Abdel Massih facility in the channel inside the factory (1.5 mg/L). However, since the sample was taken prior to discharging the bleaching water (361.4 mg/L), levels of nitrates inside the channel are expected to rise significantly after discharge.

6.12 Temperature

Temperature was measured for samples taken from Filitex and La Primera facilities, as well as from samples taken from the intersection channel. Temperature was found high (47°C; ELV: 35°C) at the outlet channel of Filitex, immediately before wastewater discharged from the facility meets with the open public channel. At La Primera, samples were taken from the softening and dyeing machines baths. Temperature measured at these locations was respectively 55 and 90°C. The baths are discharged directly into the public channel with no cooling period.
Temperatures at the intersection channel (before La Primera location) fall within ELV limits.

6.13 Comments on the wastewater analysis results

It is worth to keep in mind the following observations and comments:

- The intersection channel is supporting most of the pollution load in almost 7 of the analyzed parameters.
- All heavy metals measured (except for chromium III, Silver and lead) were below the relevant environmental limit values during two stages of sampling. However special care should be given to effluents generated from Habis facility for example, since the baths are emptied every four months and samples could not be taken at this precise time in order to assess the actual level of metals present in the released wastewater.

- Test results for BOD, COD and TSS had a good repeatability at the three different stages of sampling.
- Taking the intersection channel as a sample, the COD: BOD ratios fall within the range of 7 to 13. According to literature, a COD: BOD ratio of more than about 2.5 increases the probability of poor treatibility (% removal of COD). This is also true in case of highly variable COD: BOD ratios.
- Special care should be given to ZM Vegetable oil facility since it exceeds ELV limits in almost eight of the measured parameters.
- Oil and Grease is detected in almost nine of the selected industries. Whereas these results can be explained by the production of the facility (ZM produces vegetable oils), or the use of raw materials containing oil (Filitex), it is less comprehensible in the case of Ninex facility where high levels of Oil and Grease can only be explained by bad cleaning habits (releasing oil coming from machinery into sewers).

The relationship between the selected industries and the sources of primary pollutants is shown in the following table. Percentage of pollutants present in each industry is also indicated irrespective of the quantities of pollutants generated.

Industry	Primary Pollutants (outside limits)										% of analyzed pollutants out of limits
	pH	BOD	COD	TSS	P	Oil and Grease	Sulfides	TKN	NH_3	Heavy Metals	
ZM	•	•	•	•	•	•	•	•			80%
La Primera		•	•	•	•	•	•				60%
Abdel Massih		•	•	•	•	•	•				60%
Henkel	•	•		•	•	•					50%
Colortex		•	•				•		•		40%
Ninex		•	•			•					30%
Filitex		•	•			•					30%
Sidem				•		•				•	30%
Libano-Italienne		•		•							20%
Habis	•									•	20%
Algorithm						•					10%
Hcheimy				•							10%
Adams			•								10%

Table 15: Analyzed parameters outside ELV (Summary).

7. ROLE OF INDUSTRIES AND PUBLIC AUTHORITIES IN REDUCING POLLUTION ENVIRONMENTAL IMPACTS

7.1 Role of industries:

It is difficult to evaluate or, to be more exact, to judge the main responsible in generating the pollution in Zouk Mosbeh, between commercial establishments and industries, since exact data about the overall pollution generated is not available and need further and deeper studies. However, exact figures are not needed to point the role of each party in lowering the effects of the pollution being generated on the environment.

Some measures to lower wastes generation comprise the following:

- Waste minimization: reduce solid waste by acquiring raw materials in bulk, thus avoiding unnecessary packaging.
- Prefer the use of recycled products to others.
- Develop a clean technology. Implement good housekeeping practices and cleaner technologies; small modifications or adjustments to the process can result in less waste generation and more efficiency. According to a study made by the world bank in Indonesia, an old unproductive plant (75^{th} percentile on age; 25^{th} percentile on value added per worker) is about 2.4 times more water pollution intensive than a young and productive firm (25^{th} percentile on age; 75^{th} percentile on value added per worker)
- Sorting of solid waste at source before disposal.
- Improve the circulation of information among workers and improve responsibilities.
- More engagement of management to environmental issues.
- Identify the volume, composition, flows and costs of wastes. The more knowledge of the wastes at source, the higher the possibility to take the right actions and to make the right technical choices.
- Identify opportunities and make feasibility studies in association with all the potential stakeholders: suppliers, employees, and subcontractors....
- Better interaction between all neighboring premises.
- Improve awareness of personnel on the importance of housekeeping of liquid and wastes handling.
- Identify possible options for selling and buying wastes.

Given the increase of environmental awareness of residents of the area, it is becoming more of the interest of the industries that they keep Zouk Mosbeh industrial zone clean. However, since the benefits to such industries would be indirect and at a long term, most of them do not visualize the need to be involved in such measures (or simply cannot be involved for financial reasons). For example few of the industries surveyed were willing to pay to install pollution abatement equipment unless they are helped in financing them by public authorities, despite the fact that many of them were not only aware that they were polluting but even knew that technology is available to deal with this menace.

7.2 Role of government

Government has a crucial role to play in setting regulations to limit pollution, and in enforcing those regulations. In particular, its focus is to limit pollution at the source. Government role should also be focused to what is absolutely essential: protecting the public from clear and present danger. Moreover, government has to expand its role from pollution control to pollution prevention, and it has to take the lead in advocating, and in some cases insisting on environmentally friendly technologies.

When one looks at the scenario in Zouk Mosbeh in depth, it becomes imperative that certain incentives like tax rebates presumably by the government need to be put in place if industrialists are expected to spend money on pollution abatement.
The question of awareness on the part of the consumer could also force industrialists to start worrying about pollution abatement. For example, if consumers rejected products on grounds that they were environmentally unfriendly, industrialists would be forced to act responsibly. . This fact is currently indirectly applied, by some industries in Zouk Mosbeh that deals with international markets. Another way of enforcing environmental responsibility is for companies that do not protect the environment be denied the access to the international market. Some industries are actually spending less on production costs and are therefore enjoying an unfair advantage. A stringent approach to ensure that they do not continue to enjoy this benefit is to ensure that they play a positive role in environmental pollution control.
On the other hand, it is not just enough to insist that companies inject resources into environmental pollution control. The entire process has to be sustainable. And so how do we build sustainability in the pollution control of Zouk Mosbeh?

There are certain rules for insuring sustainability. Goldsmith, [promoting sustainability of development Institutions-1992] suggests the following for insuring sustainability:

- Securing beneficial commitment to priorities, projects and interests, in this case, the process of pollution control of Zouk Mosbeh industrial zone.
- Choosing an attainable organizational mission and allocating resources to these attainable goals.

8. CONCLUSION AND RECOMMENDATIONS

Even that the local community and authorities at Zouk Mosbeh have shown concern about environmental issues; judgment has been built mainly on visual aspects (i.e. odors, color of effluents, foams, etc). The analytical work performed within this project revealed that the actual weight of pollutants releases, mainly to water, goes deeper than just visual aspects. In fact, most of the parameters analyzed for the selected industrial sites fall outside the Environmental Limit Values (ELV) set by the Ministry of Environment in its standard for wastewater.

Important loads of phosphorous, organic matter, sulfides, suspended solids and oils are being discharged directly to seawaters on a continuous basis, a fact that will lead on the long run to saturation levels and chronic impacts on environment and health. Evidently, actions need to be taken from both, industrialists and public authorities to ameliorate this situation.

It is to note that due to the small size of most of the industries, the treatment for each water effluent *in situ* has a lot of limitations, mainly financial and operational (low volumes discharged). A lot of improvement could be made by simply implementing good housekeeping practices inside industrial facilities, without the need of highly sophisticated technologies or big investments. Also, the concept of water reuse and recycling is not generalized within the industries, even if it is feasible. Practices such as discharging used motor oils into sewers or septic tanks, is very common in the Zouk Mosbeh area.

Tough some of the industrialists in the area of study have certain environmental awareness; many of them may need extra support from local and national authorities to understand environmental issues and their impacts.

It was observed that more than half of the industries surveyed dispose used paper and cardboards along with domestic wastes. In the same way, almost 40% of them dispose wood wastes in the same manner. Public authorities should create a data bank or channels to collect wastes that have an added value (such as glass, paper, etc) and distribute them to recycling facilities.

Disposal of used motor oils into sewers should be avoided. Considering that their incineration has some negative effects on air quality, the establishment of a recycling facility for used oils should be considered as the best choice for waste management.

the substitution of substances by others that generate less hazardous waste. Recovery and recycling of wastes provide the next range of preferences, followed finally by those involving outright disposal. In general, waste management options should be directed towards the safe handling of used oil, maximization of its recycling and minimization of its disposal.

Given the increased environmental awareness and existing technologies for pollution abatement, and the desire by consumers for products of a green nature (whose production processes have positive regards for the environment), it would seem naïve for industrialists to try and save money today instead of putting it into pollution abatement strategies. It is therefore suggested that the government of the day in an effort to try to ensure a market for the industries tomorrow, i.e sustainability, should provide certain incentives for industries to see the benefits of investing in environmental protection. Any industrialists with forward planning would not be waiting for the government to provide these incentives but should instead lead the way in environmental protection.

Azar Karam	AK	ND	ND	7.71	52	-	7.7	ND	ND	-	-	-
Hcheimy	HC	ND	ND	7.69	230	-	10.8	-	ND	-	-	-
Adams	AD	1331	ND	7.47	102	-	7.7	-	ND	-	-	-

ELV	500	1500	2	10	0.1	
Sample ID	Pb(ug/l)	Cu(ug/l)	Cr(mg/l)	Zn(mg/l)	Ag(mg/l)	As(mg/l)
F1+F2+F3	72	38	1	<0.1	-	ND
H1+H2	94	48	<0.05	<0.1	-	ND
H3	104	35	<0.05	<0.1	-	ND
I	64	36	1	2	-	ND
A1	85	42	1	<0.1	-	ND
A2	48	49	1	1	-	ND
P1	30	33	<0.05	<0.1	-	ND
P2	70	34	<0.05	<0.1	-	ND
P3	91	33	<0.05	<0.1	-	ND
P4	90	35	<0.05	1	-	ND
HA1	51	7	<0.2	<0.1	ND	ND
HA2	53	7	<0.2	<0.01	ND	ND
HA3	56	7	<0.2	2	ND	ND
S1	63	6	3	<0.1	-	ND
S2	38	6	<0.2	<0.1	-	ND
S3	70	6	<0.05	<0.1	-	ND
NA	46	7	<0.2	2	-	ND
C	54	7	<0.2	<0.1	-	ND
LI	46	7	<0.2	<0.01	-	ND
AK	77	5	<0.05	1	-	ND
HC	73	5	<0.05	5	-	ND
AD	55	5	<0.05	<0.1	-	ND

Second Stage of Sampling (5 and 7 of February)

	ELV	250	100	5-9	200	40	10	16	30	5
Sample location	**Sample ID**	**COD (mg/l)**	**BOD (mg/l)**	**pH**	**TSS (mg/l)**	**TKN (mg/l)**	**NH3-N (mg/l)**	**P (mg/l)**	**Oil & Grease (mg/l)**	**Sulphides (mg/l)**
Intersection-Feb. 18	I1	1995	255.3	9.45	58	15.4	10	6.0	483	0.8
ZM	ZM	34200	4752.0	9.88	5122	38.5	<0.1	71.7	2034	260.0
Algorithm	AL	342.0	16.8	7.28	ND	12.3	8.5	2.1	106	3.8
Henkel-outside	H4	5060.0	267.0	7.93	210	15.4	--	6.8	158	<0.1
Colortex-chann. Dying	C1	1113.0	68.3	7.51	ND	--	10.8	3.1	8	0.8
Colortex-wash.,printing	C2	1821.6	266.4	7.50	156	--	15.4	2.3	27	156.0
Colortex-washing	C3	1113.0	127.5	7.38	ND	--	13.8	6.2	23	<0.1
Ninex-washing machine	N1	910.8	151.3	7.39	260	12.3	--	1.1	<0.1	--
Ninex-channel	N2	809.6	73.4	8.01	ND	18.4	--	<0.1	1348	--
Intersection-March 5	I2	404.8	14.1	9.45	256	15.4	3.1	15.0	23	<0.1
ZM	ZM1	9816.4	3720.0	9.88	13270	76.8	--	44.2	71476	280.0
Habis-chemical bath	HA4	--	--	10.74	--	--	--	--	--	--
Habis--electrochem. Bath	HA5	--	--	11.34	--	--	--	--	--	--
Intersection-March 7	I3	3542.0	267.9	12.31	274	30.7	0.0	18.2	123	--
Sidem-channel inside	S4	<0.1	7.9	7.41	750	23.0	1.5	<0.1	696	--
Libano italienne-outside	LI2	<0.1	121.6	8.00	6	12.3	4.6	<0.1	167	--
Filitex-channel inside	F4	<0.1	11.5	8.05	ND	9.2	<0.1	<0.1	113	--

	ELV	500	1500	2	10	0.1	100	10
Sample location	**Sample ID**	Pb(ug/l)	Cu(ug/l)	Cr(mg/l)	Zn(mg/l)	Ag(mg/l)	As(ug/l)	Al (mg/l)
Henkel-outside	H4	76.7	18.5	0.3	0.7	--	6.3	--
Colortex-chann. Dying	C1	92.8	12.8	0.4	0.8	--	6.5	--
Colortex-wash.,printing	C2	82.9	16.3	0.4	<0.2	--	6.6	--
Colortex-washing	C3	86.8	13.8	0.3	0.7	--	6.1	--
Ninex-washing machine	N1	45.9	14.5	0..3	<0.2	--	7.0	0.3
Ninex-channel	N2	43.6	12.4	0.3	<0.2	--	7.5	0.5
Algorithm	AL	49.9	15.7	1.0	0.5	--	5.9	--
Intersection-5 Feb.	I2	46.4	17.2	0.3	0.2	--	4.9	--
ZM	ZM	48.6	15.4	1.4	1.0	--	6.3	--
Habis-chemical bath	HA4	3778.0	123.5	0.4	1.3	0.4	7.0	0.6
Habis--electrochem. Bath	HA5	32.0	39.5	0.3	<0.2	0.2	4.6	0.5
Intersection-7 Feb.	I3	19.7	11.9	0.3	<0.2	--	7.0	--
Sidem-channel inside	S4	90.1	13.9	0.3	<0.2	--	6.5	2.9
Libano italienne-outside	LI2	66.8	25.5	0.3	<0.2	--	7.6	--
Filitex-channel inside	F4	90.1	13.9	0.3	<0.2	--	6.8	--
Intersection Feb18	I1	79.5	15.7	1.2	0.5	--	6.5	--

Environmental Limit Values (ELV) for wastewater discharged into the sea

Column 1 shows the regulated pollution parameters, column 2 gives the emission limit values for existing facilities and column 3 for new facilities. Emission limit values of Column 2 will automatically expire when the Barcelona LBS protocol is ratified by the Republic of Lebanon. In this case the emission limit values of column 3 will become automatically valid for all kinds of facilities.

The outlet of the pipeline for coastal outfalls, its length and depth should be designed according to:

- sea bed data
  - -sea bed levels
  - -sea bed soils
  - -sea bed stability or movements
- environmental data
  - -wind speed frequencies and direction
  - -local topography and effects on currents, winds and waves
  - -shipping, dredging, fishing, shell-fishery, bathing and other activities
- effluent data
- receiving water characteristics
  - -time for bacteria to die (T_{90})
  - -horizontal and lateral dispersion coefficients
  - -vertical dispersion coefficient
  - -temperature, salinity and density profiles.

1	2	3
Parameter	**ELV for existing facilities**	**ELV for new facilities**
pH	5 – 9	6 – 9
Temperature	35°C	35°C
BOD_5 mgO_2/L	100	25
COD mgO_2/L	250	125
Total Phosphorous mgP/L	16	10
Total Nitrogen mgN/L[1]	40	30
Suspended Solids mg/L	200	60
AOX	5	5

[1] Sum of Kjeldahl-N (organic N + NH_3), NO_3-N, NO_2-N

1	2	3
Parameter	**ELV for existing facilities**	**ELV for new facilities**
Detergents mg/L	3	3
Coliform Bacteria 37°C in 100 ml[2]	2,000	2,000
Salmonellae	absence	absence
Hydrocarbons mg/L	20	20
Phenol index mg/L	0.3	0.3
Oil and Grease mg/L	30	30
Total Organic Carbon (TOC) mg/L	75	75
Ammonia (NH_4^+) mg/L	10	10
Silver (Ag) mg/L	0.1	0.1
Aluminum (Al) mg/L	10	10
Arsenic (As) mg/L	0.1	0.1
Barium (Ba) mg/L	10	2
Cadmium (Cd) mg/L	0.2	0.2
Cobalt (Co) mg/L	0.5	0.5
Chromium total (Cr) mg/L	2	2
Hexavalent Chromium (Cr^{VI}) mg/L	0.5	0.2
Copper total (Cu) mg/L	1.5	1.5
Iron total (Fe) mg/L	5	5
Mercury total (Hg) mg/L	0.05	0.05
Manganese (Mn) mg/L	1	1
Nickel total (Ni) mg/L	2	0.5
Lead total (Pb) mg/L	0.5	0.5
Antimony (Sb) mg/L	0.3	0.3
Tin total (Sn) mg/L	2	2
Zinc total (Zn) mg/L	10	5
Active Cl_2 mg/L	1	1
Cyanides (CN^-)mg/L	0.1	0.1
Fluoride (F^-) mg/L	25	25
Nitrate (NO_3) mg/L	90	90
Phosphate (PO_4^{3-}) mg/L	5	5
Sulphate (SO_4^{2-}) mg/L	1,000	1,000
Sulphide (S^{2-})mg/L	5	1

2 For dischargers in close distance to bathing water a stricter ELV could be necessary.

Environmental Limit Values (ELV) for wastewater discharged into surface water

Column 1 shows the regulated pollution parameters, column 2 gives the emission limit values for existing facilities and column 3 for new facilities. Emission limit values of Column 2 will automatically expire when the Barcelona LBS protocol is ratified by the Republic of Lebanon. In this case the emission limit values of column 3 will become automatically valid for all kind of facilities.

Surface water is defined as inland water permanently or temporarily flowing in beds or flowing quickly from springs. A minimum flow of 0.1 m^3/s needs to be guaranteed when discharging.

1	2	3
Parameter	**ELV for existing facilities**	**ELV for new facilities**
pH	5 – 9	6 – 9
Temperature	30°C	30°C
BOD_5 mgO_2/L	100	25
COD mgO_2/L	250	125
Total Phosphorous mgP/L	16	10
Total Nitrogen, mgN/L[3]	40	30
Suspended Solids mg/L	200	60
AOX	5	5
Detergents mg/L	3	3
Coliform Bacteria 37°C in 100 ml[4]	2,000	2,000
Salmonellae	absence	absence
Hydrocarbons mg/L	20	20
Phenol index mg/L	0.3	0.3
Oil and Grease mg/L	30	30
Total Organic Carbon (TOC) mg/L	75	75
Ammonia (NH_4^+) mg/L	10	10
Silver (Ag) mg/L	0.1	0.1

3 Sum of Kjeldahl-N (organic N + NH_3), NO_3-N, NO_2-N

4 For dischargers in close distance to bathing water a stricter ELV could be necessary.

1	2	3
Parameter	**ELV for existing facilities**	**ELV for new facilities**
Aluminum (Al) mg/L	10	10
Arsenic (As) mg/L	0.1	0.1
Barium (Ba) mg/L	2	2
Cadmium (Cd) mg/L	0.2	0.2
Cobalt (Co) mg/L	0.5	0.5
Chromium total (Cr) mg/L	2	2
Hexavalent Chromium (Cr^{VI}) mg/L	0.5	0.2
Copper total (Cu) mg/L	1.5	0.5
Iron total (Fe) mg/L	5	5
Mercury total (Hg) mg/L	0.05	0.05
Manganese (Mn) mg/L	1	1
Nickel total (Ni) mg/L	2	0.5
Lead total (Pb) mg/L	0.5	0.5
Antimony (Sb) mg/L	0.3	0.3
Tin total (Sn) mg/L	2	2
Zinc total (Zn) mg/L	5	5
Active Cl_2 mg/L	1	1
Cyanides (CN^-)mg/L	0.1	0.1
Fluoride (F^-) mg/L	25	25
Nitrate (NO_3) mg/L	90	90
Phosphate (PO_4^{3-}) mg/L	5	5
Sulphate (SO_4^{2-}) mg/L	1,000	1,000
Sulphide (S^{2-})mg/L	1	1

Environmental Limit Values (ELV) for wastewater discharged into the sewerage system

Column 1 shows the regulated pollution parameters, column 2 gives the emission limit values for existing facilities and column 3 for new facilities. Emission limit values of Column 2 will automatically expire when the Barcelona LBS protocol is ratified by the Republic of Lebanon. In this case the emission limit values of column 3 will become automatically valid for all kind of facilities.

Dischargers can agree divergent emission limit values for discharging wastewater to the sewage system with the operator of the sewage treatment plant as long as the respective emission limit values are kept at the outlet of the sewage treatment plant.

1	2	3
Parameter	**ELV for existing facilities**	**ELV for new facilities**
pH	6 – 9	6 – 9
Temperature	35°C	35°C
BOD_5 mgO_2/L[5]	125	125
COD mgO_2/L[6]	500	500
Total Phosphorous mgP/L[7]	10	10
Total Nitrogen, TN mg/L[8]	60	60
Suspended Solids mg/L	600	600
AOX	5	5
Salmonellae	absence	absence
Hydrocarbons mg/L	20	20
Phenol index mg/L	5	5
Oil and Grease mg/L	50	50
Total Organic Carbon (TOC) mg/L	750	750
Ammonia (NH^{4+}) mg/L[9]	-	-

5 Assuming an outlet concentration of 25 mg/l and a cleaning capacity of 80%

6 Assuming an outlet concentration of 125 mg/L and a cleaning capacity of 75%

7 Assuming an outlet concentration of 2 mg/l and a cleaning capacity of 80%

8 Assuming connection to a biological wastewater treatment plant. Performance of waste water treatment plant related to the concentration in the inflow: 70 – 80%, ELV at outlet: 15 mg/L N

1	2	3
Parameter	**ELV for existing facilities**	**ELV for new facilities**
Silver (Ag) mg/L	0.1	0.1
Aluminum (Al) mg/L	10	10
Arsenic (As) mg/L	0.1	0.1
Barium (Ba) mg/L	2	2
Cadmium (Cd) mg/L	0.2	0.2
Cobalt (Co) mg/L	1	1
Chromium total (Cr) mg/L	2	2
Hexavalent Chromium (Cr^{VI}) mg/L	0.2	0.2
Copper total (Cu) mg/L[10]	1	1
Iron total (Fe) mg/L	5	5
Mercury total (Hg) mg/L	0.05	0.05
Manganese (Mn) mg/L	1	1
Nickel total (Ni) mg/L[11]	2	2
Lead total (Pb) mg/L[12]	1	1
Antimony (Sb) mg/L	0.3	0.3
Tin total (Sn) mg/L	2	2
Zinc total (Zn) mg/L[13]	10	10
Cyanides (CN^-)mg/L	1	1
Fluoride (F^-) mg/L	15	15
Nitrate (NO_3) mg/L[14]	-	-
Phosphate (PO_4^{3-}) mg/L[15]	-	-
Sulphate (SO_4^{2-}) mg/L	1,000	1,000
Sulphide (S^{2-})mg/L	1	1

9 Assuming connection to a biological wastewater treatment plant. Performance of waste water treatment plant related to the concentration in the inflow: 70 – 80%, ELV at outlet: 15 mg/l N

10 ELV of 0.5 mg/L must be kept at the outlet of WWTP.

11 ELV of 0.5 mg/L must be kept at the WWTP outlet.

12 ELV of 0.5 mg/L must be kept at the WWTP outlet.

13 ELV of 5 mg/L must be kept at the WWTP outlet.

14 ELV for total nitrogen has to be kept

15 ELV for total phosphor has to be kept