The Scrap Metal Processing Industry in Benin Exposed to Low Doses of Ionising Radiation

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Article

The Scrap Metal Processing Industry in Benin Exposed to Low Doses of Ionising Radiation

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Abstract

The scrap metal waste exploitation sector has many advantages but is not without risks for workers exposed to low doses of radiation. The aim of this study was to collect information on the frequency and distribution of illnesses occurring among the staff of the company "Atlantic Control". This was a descriptive cross-sectional study with retrospective and prospective collection of data on the health status of workers. Data were analyzed using Epi Info and SPSS software. In total, 75 agents working for 10 years in radioactive scrap metal waste and 45 agents working for 5 years were included in this study. Of the 75 agents working in radioactive scrap metal over 10 years, we noted that 2/3 of the agents suffered from fatigue, tachycardia and permanent and constant shortness of breath; 81.33% eye irritation; 14.67% myelemia; 29.33% subfertility;41.33% splenomegaly and 20% thyroid mass. Also, the health check examinations of 45 agents working in radioactive scrap metal over 5 years indicate33.33% cases of red spots on the body and fatigue; 35.55% poly leukocytosis; 31.11% discreet splenomegaly; 13.33% thyroid micronodule and 24.44% severe anemia. None of the workersdid not present these pathologies either when hired or after three yearss of exercise. These cases could be attributable to exposure to low doses of radiation.

Keywords: scrap metal waste; exposure; ionizing radiation; pathologies

Introduction

The scrap metal industry plays an essential role in the circular economy, enabling metals to be recycled and reused [1]. This industry helps to reduce waste, conserve resources and cut pollution. [2,3]. However, despite its many advantages and potential, this sector exposes its workers to significant risks. Workers in the scrap metal industry are exposed to many occupational hazards, including exposure to toxic substances (heavy metals, industrial solvents) and ionising radiation [4,5]. These working conditions can lead to a wide range of health problems, from respiratory problems to skin diseases, gastrointestinal problems and cancer [6]. What's more, the radiological risks involved in the recycling of scrap metal add an extra dimension of complexity and danger to this situation. Several studies have shown that exposure to even small doses of radiation can have harmful effects on health, including cancer, eye disease and cardiovascular disease [7]. Aware of these risks, several developed countries have put in place a strict regulatory framework and advanced research into the knowledge and control of pathologies linked to radiological exposure [8,9].

However, in Africa, and particularly in Benin, there is still a lot of work to be done to get a true picture of professional exposure on the continent [10]. This poses a number of challenges, one of the most important of which is undoubtedly the characterisation of the correlation between exposure

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doses and the frequency of onset of certain pathologies, which is not always obvious. Even on a global scale, a number of studies have highlighted the difficulties associated with this issue, and the results of several studies are sometimes not unanimous with regard to these relationships [11,12]. Given the weakness of the regulatory framework and the limitations that still exist in terms of radiation protection in Africa, the problem of actually estimating the correlation between different levels of radiation and the frequency of certain pathologies could prove even more worrying [13,14]. These factors limit the ability to better organise worker protection measures and to carry out more targeted and therefore more efficient public health interventions.

The aim of this study, entitled 'Occurrence of pathologies linked to the exposure of scrap metal workers to low doses of ionising radiation in Benin', will therefore be to establish the relationship between low doses of ionising radiation and certain pathologies in workers in the scrap metal industry in Benin, and in particular in workers at ATLANTIC CONTROL S.A., in order to contribute to efforts to meet these challenges.

Study Framework, Materials and Methods

Study Framework

The study took place in Cotonou at the work site of Atlantic Contrôle in Akpakpa in the Littoral department in the commune of Cotonou. Specifically the site of the former SONICOG Company not far from the Cotonou lagoon and its surroundings from 2 September 2017 to 31 March 2018. Figure 1 shows a map of the city of Cotonou.

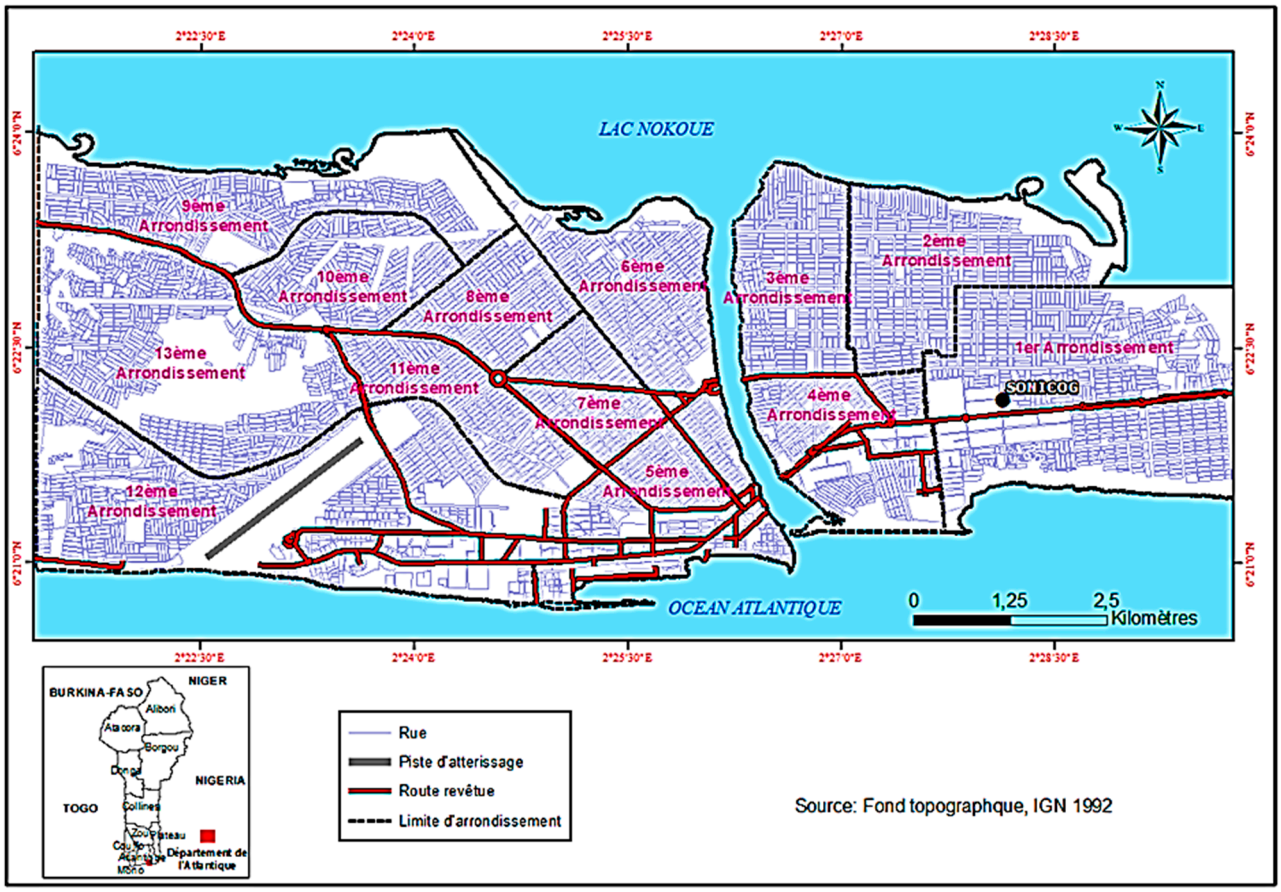

Figure 1. Map of the city of Cotonou.

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Materials

The dose was measured using a calibrated AUTOMEX radiometer. The Terra-P+ radiometer is a multi-purpose radiometer with a technical dose integration function. It measures the dose rate directly and integrates the H dose. It differs from the Terra-P in that it has a wider dose rate measurement range, a backlit screen and a beta contamination measurement function (with automatic subtraction of the gamma background). The Terra-P radiometer detects radioactivity directly.

Method

The sampling method used was two-stage sampling.

- The first stage consisted of all 'Atlantic Contrôle' personnel wearing a calibrated AUTOMEX-type dosimeter, working in direct contact with scrap metal that emits low levels of ionising radiation without personal protective equipment (PPE).
- Secondly, the personnel interviewed on the scrap metal sites emitting low levels of ionising radiation without a dosimeter and without PPE.

A survey form was drawn up and distributed to all staff working in the company and divided into four categories:

- A1: Group of employees who had been working at the company for at least 10 years and were in direct contact with scrap metal, wearing a dosimeter but without PPE.
- A2: Employees who have worked in the company for at least 10 years without a dosimeter and without PPE
- A3: Group of operatives working in the company for at least 5 years and in direct contact with scrap metal with dosimeter and without PPE
- A4: Group of operatives working in the company for at least 5 years, in direct contact with scrap metal without a dosimeter and without PPE.

Retrospective data were collected from staff health registers showing the results of health assessments over 10 years of working in low-level ionising radiation without a dosimeter or personal protective equipment. The prospective phase involved interviewing and measuring the dose of personnel who had worked in direct contact with scrap metal without personal protective equipment but who wore a dosimeter.

Data Collection and Analysis

The data To carry out this study, a survey form was drawn up and distributed to all Atlantic Contrôle staff. Interviews were conducted on the basis of the questionnaire on the form. The questions were structured so as to collect information on family history, medical history, surgical history, biological immunity, radiological risks, dosimetric and medical monitoring, and the various illnesses contracted by staff exposed to low-dose radiation over the last 5 to 10 years. The data was processed using SPSS and EPI info software. Microsoft Excel and Arcvrewr were used to produce graphs and maps.

Results

A total of 75 employees who had been working with radioactive scrap metal for 10 years and 45 employees who had been working for 5 years were included in the study. Table 1 shows the calculation of the maximum annual dose due to external exposure

Table 1. Calculation of maximum annual dose due to external exposure.

Samples	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**
Dose rate (μ S v)	6.90	4.51	1.75	2.23	0.9	14

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Annual effective dose (mSv)	7.17	4.70	1.82	2.32	0.93	7.4

From 2013 to 2017, we can see that annual doses accumulate over the years, and the accumulation curve is linear. Figure 1 shows cumulative doses by year.

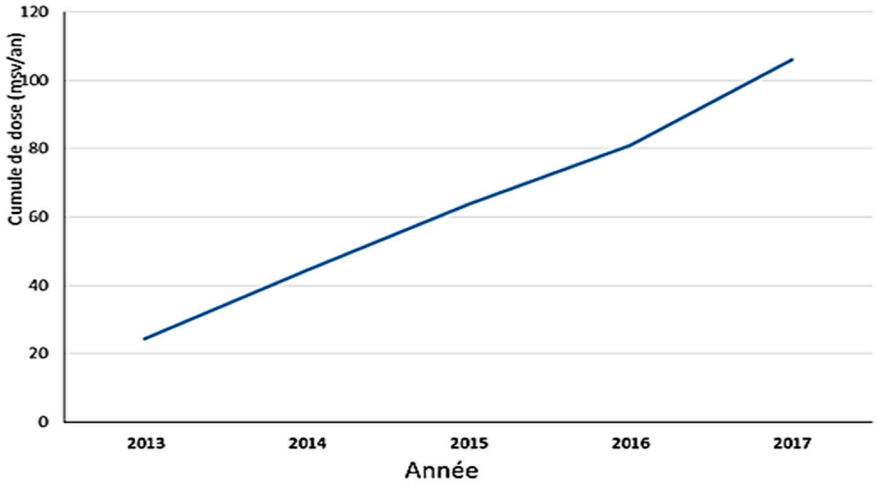

Figure 2. Cumulative doses by year.

Table 2 shows the classification of pathologies according to accumulations of low doses of ionising radiation: prospective study of group A1 health assessments.

Table 2. Classification of pathologies according to cumulative low doses of ionising radiation: prospective study of group A1 health check-ups.

Cumulative dose (m.s.v)	**0 – 50**	50 **– 100**	**> 100**
Diseases	-Dermatitis -Eye irritation -Chronic lung disease	-Poly leukocytosis -Anemia -Hypofertility	-Splenomegaly -Myeloma -Thyroid mass
Number of cases	-15 cases of dermatitis -16 cases of eye irritation - 6 cases of chronic pneumopathy	- 16 cases of polyleukocytosis - 11 cases of anaemia - 8 cases of hypofertility	-31 cases of splenomegaly -11 cases of myeloma -15 cases of thyroid mass
Number of years	3 years old	5 years old	10 years old

Table 2 shows the pathologies of operatives working in the company for at least 10 years without a dosimeter and without group A2 PPE.

Table 3. Pathologies of operatives working in the company for at least 10 years without a dosimeter and without group A2 PPE.

Type of examination	**Results**	**Number**	**Comments**
Medical consultation	Shortness of breath, fatigue and tachycardia	51 cases	

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Ophthalmological consultation	Cataracts Eye irritation	8 cases 61 cases	
Laboratory examination			
CBC	- Polyleukocytosis - Immature cell (young)	- 31 cases - 11 cases	Myeloma
Spermogram	- Azoospermie - Oligospermie	- 04 cases - 22 cases	Infertility Infertility
H.S.T.	5 to 10 mUI/L	- 15 cases	
T3	0.1 to 1.5	- 8 cases	Hypothyroidism
T4	18 to 25 ng/L	- 14 cases	Hyperthyroidism

- The results of a retrospective study of health assessments carried out on 75 workers who had been working in radioactive scrap metal for 10 years and 45 workers who had been working for 5 years revealed the appearance of certain illnesses as a function of the cumulative dose and the duration of exposure.
- Table 2 shows some of the health check-ups carried out on 75 operatives working in radioactive scrap metal over a 10-year period, wearing a dosimeter and without personal protective equipment:
- 51 cases, i.e. 2/3 of the agents, of fatigue, tachycardia and permanent and constant shortness of breath
- 61 cases (81.33%) of eye irritation
- 11 cases (14.67%) of myelemia
- 22 cases (29.33%) of hypofertility

In addition to these types of disease, there were 31 cases of splenomegaly (41.33%) and 15 cases of thyroid mass (20%).

In addition, the health check-ups carried out on 45 employees working in radioactive scrap metal over a period of 5 years revealed:

- 15 cases (33.33%) of red spots on the body and fatigue
- 16 cases of 35.55% poly leukocytosis
- 14 cases (31.11%) of discrete splenomegaly
- 6 cases (13.33%) thyroid micronodule
- 11 cases (24.44%) with severe anaemia

All of these employees (A1 and A2) did not suffer from these diseases either on recruitment or during the first three years of their career, nor did employees working with personal protective equipment.

Discussion

The question of the occurrence of pathologies among workers in the scrap metal industry, exposed to low doses of ionising radiation, raises crucial concerns about health and safety at work in this little-known sector. One of the hypotheses adopted is that when exposed to ionising radiation, cells, tissues and the body react in different ways depending on the dose and dose rate [15]. These differences may explain the singularity of the ailments identified in our study as a function of the different cumulative doses of ionising radiation collected following the prospective collection of health assessments in our study population (Table 2).

The results of this study showed that two-thirds of the operatives who had been working for ten years suffered from permanent shortness of breath, fatigue and tachycardia, with possible cardiovascular pathologies as highlighted in a study by Baselet and al. [16] in 2016. However, this study does not agree on the dose necessary for the appearance of symptoms above 50 mSv, unlike

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the Wakeford study in 2019 [17], also supporting a correlation between exposure doses and the effects observed. However, this study only focused on probable heart disease. These results are also consistent with those of Poole and Basu in 2017 [18]. It also emerged that the majority of individuals (81%) had eye irritation, as reported by Schantora and al. [19] (strongly work-related) and Poulsen and al. [20] in a study of workers in the recycling industry, although it did not consider only exposure to ionising radiation. According to this study, the effects occur more frequently in the case of exposure to bio-aerosols.

Our study reports the existence of 8 cases of hypothyroidism, which may explain the persistent fatigue of the agents, and 14 cases of hyperthyroidism, which may explain the permanent tachycardia. This finding is consistent with those of the study by Okeme and al. who reported high levels of thyroid hormones (T4 and T3) [21]. We also noted the existence of 6 cases of chronic lung disease, a finding reported in the systematic review by Poole and al. [18] which reported the existence of respiratory disorders with increased risks of occupational asthma, extrinsic allergic alveolitis, allergic bronchopulmonary aspergillosis and pulmonary function abnormalities in workers exposed to compost compared with controls.

We also noted 14.67% cases of myeloma and 29.33% cases of hypofertility. Several similar studies have revealed an association between exposure to ionising radiation and infertility and cancer. These include Doyle and al.[23] and Azizova and Brenner [24,25]. These studies have revealed a strong correlation between exposure and infertility (male and female) and the occurrence of cancers, particularly dermatological and neurological cancers. The same is true of studies of Hiroshima and Nagasaki survivors [15].

However, it should be noted that this study did not use statistical tests to show any correlation between the occurrence of pathologies and exposure to radiation. This being the case, an experimental epidemiological study would have produced irrefutable results. In addition, in order to ensure a certain correlation, the medical check-ups of the subjects prior to the start of their work in scrap metal were taken into account. Despite this provision, there is still some uncertainty as to the causal link when we consider that in the usual environment or the different environments frequented by different individuals, there are also exposure factors that can produce the same effects [18,26,27].

Nevertheless, the results of this study are of interest given that exposure was measured. Indeed, it provides evidence for the consideration of the results obtained here as well as avenues for improving understanding in this area. The results obtained here should provide a basis for designing further experimental studies to further explore this topic and its implications.

Conclusions

The effects of ionising radiation from scrap metal on the health of exposed populations were assessed by means of a prospective study and a retrospective study, both of which produced concordant results. The correlation between the cumulative doses and the doses absorbed by the recyclers and the appearance of certain pathologies revealed the gradual appearance of pathologies such as: 14.67% of cases of myeloma, 29.33% of cases of hypofertility, 02 cases of thyroid mass and 68% of cases of fatigue, tachycardia and permanent and constant breathlessness. None of the company's 75 employees had any of these conditions either on recruitment or after three years with the company.

It can be concluded that the nature of the biological responses induced by low doses of irradiation from scrap metal differs from those induced by high doses of irradiation. The dose-effect relationships vary according to the importance of genetic predisposition in individual sensitivity to low doses of irradiation. Finally, all these results suggest that the appearance of radiation-induced cancer may be the consequence of direct irradiation of an organ, but could also be the consequence of irradiation of cells in another organ through indirect damage.

Author Contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Francis T. M. HOUNSOU, Alphonse Sako AVOCEFOHOUN,

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