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A Socio-Environmental History of a Copper Mining Company: Rio-Tinto Company Limited (1874–1930)

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Abstract: Mining activities cause serious pollution problems that affect health and the environment. This paper focuses on the environmental and biological effects that mining activity had on the population living and working in the Riotinto-Nerva area in the last third of the nineteenth century and the early twentieth century, when this area accounted for approximately 10% of world copper production. To do so, we explore the social, technological, and scientific responses to environmental pollution caused by mining extraction in this area during industrialisation. Second, we analyse welfare indicators, such as the heights of conscripts and mortality rates, so as to examine the social effects of the mining activity. Third, municipal health and education expenditures are examined to study the intervention made by the local authorities to address the welfare problems caused by the mining work and environment. Finally, we examine whether the health policy had positive effects on the health of the population after the negative external effects of copper mining in this area had been mitigated. The findings show that the negative impacts of copper exploitation on the environment and welfare could only be diminished using health policies to combat this kind of urban penalty.

Keywords: mining sustainability; pollution; industrialisation; public intervention

1. Introduction

Mining activities have exponentially risen over the last two centuries in order to provide the many primary resources required by industries throughout the world [1–4]. The increase in the population and global demand multiplied the needs for both mineral and energy resources, and mining responded to the process of industrialisation [5–7]. However, since then, mining has given rise to severe environmental and social effects [8]. This paper examines these negative external effects of mining extraction in the area of Riotinto-Nerva during the industrialisation period and explores the role played by the public sector in mitigating these externalities. Our hypothesis is that the paternalistic socio-labour policies, as well as the technological solutions implemented by the Rio Tinto Company Limited (hereafter, RTCL), were insufficient to avoid the welfare and environmental problems, and that public intervention was necessary to alleviate them. The article contributes to the literature in at least three ways: first, it analyses the links between the mining activities, their repercussions on living standards measured through welfare indicators, and the socio-technological reactions to this problem. Second, it assesses these responses and quantifies the public intervention. Third, it argues that the response of the RTCL to the smoke problem could be considered a precedent of current corporate sustainability.

The historic mineral ores in the Iberian Pyrite Belt, which are known to have existed since Early Antiquity [9], were exploited again at the end of the nineteenth century by several international mining companies, the most important of them being the RTCL, mainly based in Riotinto-Nerva

[10–12] (Figure 1). The population grew by over 83% in this area to provide the company with workers, who were concentrated in these towns [13]. At the turn of the century, the RTLC accounted for 10% of world copper production, therefore leading the world sulphur market in 1914 [14–16]. However, this article does not seek to analyse its spectacular economic success, but its social and environmental impact.

The RTCL arrived in Huelva in 1873 and, from 1876, an intense protest movement rose, culminating in the "Year of the Shots" (1888), when a pacific demonstration of farmers, workers, and miners ended in tragedy (with probably more than two hundred deaths) [17–19]. Similarly to other copper mining basins, this type of atmospheric pollution led to serious social problems from the end of the nineteenth century. The first part of this paper addresses the organisation of civil society against the smoke, the institutional initiatives, and the technological and, especially, scientific strategies regarding mining pollution. We approach this by meticulously explaining the chronological evolution of these reactions into the negative external effects of mining in the area of study. The second part studies the impact of the pyrite exploitation on the biological welfare of the Riotinto population by analysing the evolution of the heights of recruits and crude mortality rates. To do this, we analyse the anthropometric and demographic data provided by some colleagues. Third, we compile the archive data and reconstruct the public expenditures made by the local authorities in order to intervene and solve the environmental and health problems caused by the mining activity. Finally, the article ends by presenting some conclusions.

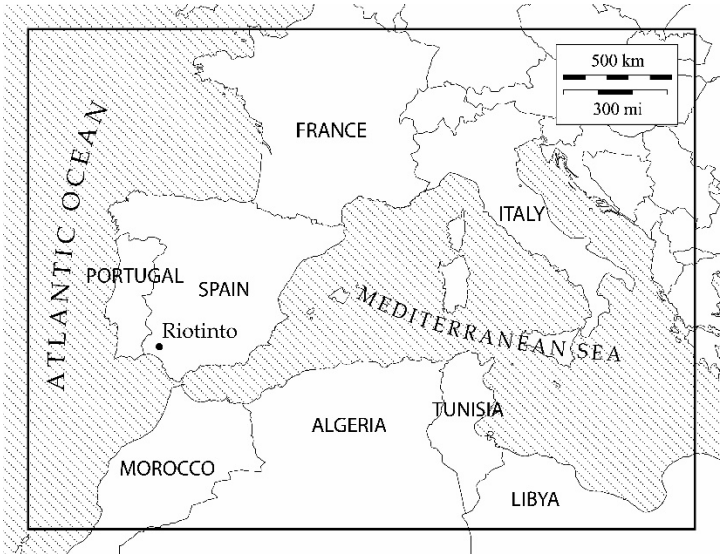

Figure 1. Map of Spain showing the location of Riotinto. Source: Own elaboration.

2. Pollution, Health, and Ecosystems

The environmental effects of mining have been studied transnationally, giving rise to different interpretations of this phenomenon and several models of action in each area [20]. Economists and economic historians have traditionally considered the socio-environmental problems of economic and technical progress from a labour–capital conflict point of view [21]. From this perspective, the problems would be the deterioration in the standard of living of farmers and workers, a high dependence on the labour market, and the concentration of the profits derived from the process in capitalist hands [22,23]. Geographers, sociologists, and historians (including economic historians) have focused on the environmental conflicts and their influence on industrial, labour, and technological policies [24–27]. Recent studies consider that the environmental movements and the induction of technical and political strategies have not achieved the deceleration of extractive practices [8]. Our contribution is the study of this process in the case of Riotinto-Nerva during industrialisation and the analysis of the responses given by society and the public sector.

A long string of mining pollution conflicts preceded the arrival of the RTCL. Both the high-grade sulphur (50%) and copper (2–3%) content of the Huelva pyrites, together with the

traditional calcining systems that allowed low costs, yielded high profits [10]. However, from the mid-nineteenth century, the smoke generated by heap roasting ("*teleras*") had an impact on health and ecosystems that gave rise to divided opinions [28]. For example, the devastating effect of this smoke on a peasant orchard located in the mining basin was the origin of the first national administrative complaint in this respect (1847) [29]. However, just a few years later, the Director of this mine not only pointed out the innocuous nature of the mining fumes, but commended their prophylactic properties despite the official report issued before the purchase of the mines by the RTCL (1873), which warned of the harmful influence of smelter smoke on plants and animals [30].

The RTCL arrived in Huelva with the intention of continuing the practice of heap roasting, a cheap but very polluting method [31]. Although the purchase contract signed with the Government established a limit to the number of *teleras*, this was very soon surpassed due to the political influence of this company [18]. From 1876, intense protest movements arose within the mining basin's local councils against heap roasting in order to protect the interests of farmers and workers, whose activities were affected by pollution and public health [32]. The damage inflicted by smoke on crops and livestock ignited the first protests reacting to how the traditional way of life in the villages was being threatened. As the intensity of both the atmospheric pollution and the size of the affected area grew, rural society weakened. The workers protested for both professional and health reasons: during the so-called "blanket" days, it was impossible to work, and the community asserted its right to fresh and clean air. The protest campaign continued until February 1888, when a pacific demonstration of farmers and miners ended in tragedy: the army charged against them, resulting in an official death toll of thirteen people, although there were probably more than two hundred [33]. Responsibilities in the massacre were not elucidated [34].

2.1. Anti-Smokers and the Narrative on Pollution

One of the most surprising aspects of this problem is the construction of an original and early discourse on pollution by the social agents involved. With a strategy similar to that adopted by the contemporary movement of resistance against mining, the anti-smoke league had the ability to "jump the scale" of this conflict, publishing a series of articles from 1878 in relevant national journals (La Epoca, El Siglo Futuro, etc.). They elaborated a discourse emphasising the contradictions of the growth model of development proposed by the mining companies, and defended the "cause of property, health, and justice" [8,35,36].

The RTLC reacted late. From the second part of the 1880s, its management promoted the elaboration and publication of articles, conferences, public reports, and internal documents, such as the series of "Smoke Pamphlets" [11]. Consistent with legal and market rules, the reiterative use of legal jargon and resorting to the mathematization of discourse was very typical of the company's editorial line [37]. In this respect, the RTLC made a cost–benefit analysis (Figure 2 and Figure 3) to support its opinions, as some other companies were doing in the Iberian Peninsula at this time (e.g., São Domingos in Portugal).

RTCL (1886)			
Properties	**Pesetas**		
The mines	84,707,000	**Towns affected by the fumes of RTCL (1887–1888)**	
Railway, pier, tunnel, railway workshop and rolling stock	27,660,775	**Properties**	**Pesetas**
Buildings, workshops, reservoirs, fixed plant, tramways, machinery, movable plant, and lands	27,049,550	Rural Property	220,999
Ore extratced and locally treated and in stock, also manufactured copper in stock in Spain and England, and produced afloat, etc	20,645,600	Town Property	488,283
Land and other properties	22,342,625	Pastoral Property	34,992
TOTAL	**182,405,550**		**744,274**

Figure 2. Cost–benefit analysis: Properties (Source: [38]).

RTCL (1886)		
Type of tax	**Pesetas**	
Paid to the State, Ore tax of 1%	48,222	
Land tax, Income tax, Property tasx	95,565	**Towns Affected by Smoke of RTMC (1887–1888)**
Custom and Port Dues	750,000	Tax (pesetas)
TOTAL	**893,787**	**132,971**

Figure 3. Cost–benefit analysis: Tax (Source: [38]).

A matter of deep concern for the British company was the robust defence of the three main lines of arguments: political and economic, technological, and scientific.

2.2. A Harmonised Solution

For the RTCL, the contract with the Government entitled it to all the property rights of the soil and the subsoil as well as the full liberty to use the most convenient method of exploitation [38]. However, from 1876, the existing problems of atmospheric pollution in Huelva and the experiences in other mining basins [39,40] led the company to concede to the payment of compensations. With the objective of standardising the cost of these compensations, the company organised the affected lands into several areas according to the damage inflicted [41]. Similarly to what had happened in other mining districts, voluntary agreements with peasants and farmers were common in the first phase of this conflict. Soon, however, parties had to solve their differences in court: as a matter of fact, a pioneering sentence (1866) against Tharsis Sulphur and Copper Company in Huelva was passed [42].

The waste of time and money and the unpredictable character of these sentences led corporations to seek an arbitration system promoted by the government and based on compensation awards. After the massacre of 1888, the Decree of the 29th February, which temporarily banned heap roasting, was a warning signal. The pressure to repeal the Decree and to pass another legal pro-business measure was enormous. Finally, the pressure took its effects. The "*Reglamento Provisional para la indemnización de los daños y perjuicios causados a la agricultura por las industrias mineras*" (1890) allowed those affected to combine court cases with an original and early procedure of public intermediation between parties, a practice implemented in other large mining basins around the world in the first half of the twentieth century [8]. A new phase in this conflict started from the 1890s, the "ordained protest": it is significant, in this respect, that the League against

Calcining was dissolved, and several members organised a new association that was exclusively dedicated to managing the compensations [43].

2.3. The Role of Technology

In addition to the increase in the scale of mining operations in the region, not only in south-west Spain, but in the border areas of Portugal, since the 1840s (with another leap in the early 1880s), at the heart of this controversy was the role of technology. The mining boom can be measured as the curve of the number of explorations and extractions, which increased from 376,000 tons in 1876 to 1.9 million tons in the final years of the nineteenth century [20]. In this paper, we focus on the second cause, the evolution of technology. According to the purchasing contract of the mine, the company did not feel compelled to use a method of treatment alternative to the *teleras*, and only in 1895 adopted the hydro-metallurgy system, used by its competitor, Tharsis Sulphur and Copper Company, since the 1880s [10]. The method involved natural leaching or natural cementation, and it was adapted to treat low-grade copper, thus allowing the treatment of great amounts of copper and the recovery of part of the sulphur. This was adapted to the technical innovations arriving from the U.S., the Bessemer converter (1901), and the pyritic smelting method (1907), which did not require a previous calcination process and needed less fuel [9,44].

Company technicians visiting the US at the beginning of the twentieth century favoured a "technological revolution". However, heap roasting did not vanish from the Huelva Basin until 1907, and the disappearance of *teleras* did not mean the end of the problem. In order to mitigate the smelter smoke, the RTCL built giant stacks. The best known one was "*Chimenea Pirita*" (1904–1919), which was located on a hill 439 m above mean sea level, and was 159 m high [10,11]. The construction of these chimneys reduced pollution problems "in situ", thus relieving the effects on the workers' health, although the effect of smoke dispersion substantially increased the extension of the polluted area and the number of those affected. An official document, accepted by the three important companies (Tharsis Sulphur Company, Los Silos, and RTCL), determined that the extension of the area affected by smoke was around 2000 km^2 (20% of the province surface). However, the figures for the province are underestimated; we know that the smoke reached the north of the province of Seville (Castillo de los Guardas). The basins of the rivers Tinto and Odiel were seriously polluted (the problem of "*aguas agrias*"), and the impacts were evident in Gibraleón, a town 60 km from Riotinto. Although the air pollution was the cause of the social reaction due to its visible consequences on health and agriculture, the environmental problem was affecting water in the same wider area too.

Modern methods of electric precipitation and filtration that reduce toxic fume emissions also arrived from the USA. However, the installation of Cottrell Precipitators in the 1920s and, particularly, of dust condensers, was only introduced in the 1930s.

Since the 1880s, the RTCL had been performing several experiments to produce sulphuric acid, without any success. In 1904, a new superphosphate plant was built in Huelva, together with a sulphuric acid plant and a new company created to market them (*Productos Químicos de Huelva S.A.*). Phosphate mines in North Africa were bought to supply them, and their products were introduced in the difficult North American fertilizer market. In 1913, two new plants for the treatment of pyrite were built. After the Great War, the recovery of brimstone from the Orkla Process started [44].

Few steps were being introduced to control water pollution, although the use of hydro-metallurgy was generating large amounts of waste. As a matter of fact, in the 1890s, there was an international conflict between Mason and Barry, owner of the Sao Domingo mine (Alentejo, Portugal), and the RTCL regarding the treatment of polluting discharges into the Guadiana River and the most appropriate decantation system [38,45].

2.4. The Scientific Controversy

Academic researchers had been studying the effects of mining fumes on health and plants since the first half of the nineteenth century. In Huelva, the controversy arose after the arrival of the large-scale mining companies. Significantly, the official report of the purchase of Riotinto mines

(1873) describes this phenomenon. Before that, in 1870, a scientific commission had published another report ending with this significant remark: "Plant life is impossible; animal life, difficult" [46].

The anti-smoke league made an early, if limited, use of scientific research. For example, in 1878, the provincial government hired an agronomist who certified the serious damage of vegetation and animals in an area with a radius of more of 15 km around Riotinto. Later, in 1886, at the request of the Owners Society and the local government of Calañas, two agronomists elaborated a complete field study and a well-informed report about the negative consequences of the smoke in this municipality [47].

Unlike the American mining corporation in the first half of the twentieth century, the RTCL did not promote research commissions [34]. The company preferred to use its team of specialists and, only occasionally, recruited external scholars. The objective was not so much to improve the scientific knowledge as to establish a range of economic values according to the type of damage. This was particularly the case after the *Reglamento Provisional* (1890), when the effects of smoke on vegetation were called into question with respect to compensation, in line with the interests of the company [8].

The consequences of smoke on health, however, gave rise to an intense and interesting scientific controversy. From the 1870s onwards, the anti-smoke league considered the smoke problem a "public health" issue because it affected the whole community [48]. A team of local doctors from the Provincial Hospital supported this point of view. Their clinical experience showed a high incidence of respiratory diseases in patients coming from the mining basin. Moreover, they reported an evident relation of causality between the copper smoke and these pathologies. However, several doctors of the mining towns (on the payroll of the RTCL) denied the toxic effects of atmospheric mining pollution, and even emphasised its antiseptic nature.

The severity of the problem led the Spanish government to create a commission of the Royal Academy of Medicine (RAM). Its final report was strongly influenced by the research of one of its members, who rejected the conclusions of the Provincial Hospital´s doctors on the grounds of their scientific weakness and questionable methodology. For him, modern research in this field had to distinguish between the health effects of gas and solid particles released by heap and industrial chimneys. In the first case, according to the opinion of the most prestigious scholars, it was not possible to link the gas components of smoke, such as sulphuric dioxide, to respiratory ailments. However, there was a solid scientific line that related solid particles to certain diseases. Therefore, it would not be a "public health" problem, but a "hygienic problem", limited to the work environment [49].

The conclusions of the report of the RAM were unanimously accepted, marking the end of a long and fruitful scientific controversy in the basin. After that, health problems were limited to the field of occupational diseases [34,50].

3. The Biological Consequences of the Mining Activity

After solving technical and financial problems in the 1870s, Riotinto became the most important European mining basin [10], and the RTCL became the world's leading company in terms of the volume of minerals extracted between 1877 and 1891 and remained among the top four companies after then [51]. However, the successful exploitation of the minerals in Riotinto seriously damaged not only the environment, but the health and welfare of the population living around the mines.

After having analysed the socio-technical responses to environmental pollution caused by the mining activity, we will now attempt to examine the effects on health by studying the evolution of different welfare indicators. This methodology has been widely used in economics and economic history when studying the impact of the industrialisation process and other economic changes on living standards [52]. Several researchers have reconstructed biological welfare indicators that we can use to analyse the negative external effects caused by ore extraction [53]. The indicators we propose are both anthropometrical, such as the height of the conscripts that had lived since the 1870s

in the area of Zalamea la Real (near the Riotinto mines) and Nerva, and demographic, such as the mortality rates of the populations living in those mining towns.

The first indicator to be analysed is the height of the recruits. Historians and economists consider this indicator to be a good measure of the standard of living because it reflects many of the monetary and non-monetary components of welfare. It would provide information on real income through nutrition and information on the environmental, sanitary, educational, labour, and demographic conditions through morbidity and physical wear and tear [54]. In addition to genetics, height is derived from the net nutritional input, that is, the difference between the crude nutritional input and the energy consumed by the individual due to activity, metabolism, and disease, so it is a good indicator of the biological standard of living [55,56]. Researchers believe that height did not have an upward evolution throughout history, but it experienced several stages with upward and downward cycles [57]. Height can be highly variable depending on genetics, but also on geography, place of residence, culture, or the environment, so it has been used as an indicator of biological welfare for decades [58].

The evolution of heights in Riotinto during the nineteenth century and the first third of the twentieth have been studied in depth [59]. The results obtained can be observed in Figure 8. They confirm that the height of the recruits declined during the mining boom (1832–1935), and the increase in inequality particularly affected immigrants and illiterates. Moreover, researchers found a slight improvement in the height of cohorts born between 1880 and 1900 (coinciding with the consolidation of the RTCL in the exploitation of the mines) and a dramatic drop when the mining crisis began in the first decades of the twentieth century.

The second biological indicator is the mortality rate. Mortality has been extensively used as a welfare indicator by demographers, historians, and economists for decades [60–71]. As a synthetic indicator, mortality contains information on nutrition and on environmental, living, and working conditions. Although the relation between mortality and nutrition has been widely studied, the data do not show a perfect correlation between the intake of food, illnesses, and the drop in mortality [72]. Many authors consider that undernourishment increases the frequency, importance, and length of illnesses (infectious or not), increasing mortality rates [73]. However, this claim has been brought into question because the improvement in the nutritional status seems not to be the most important reason for the drop in mortality since the nineteenth century; thus, cultural, environmental, and economic factors must be considered [74,75].

The evolution of the demographic indicators in the area of Riotinto is well known by specialists due to the high quality of the studies carried out by different researchers who have been working on these questions in recent decades. Some authors consider Riotinto, Nerva, Zalamea la Real, and Campillo as the towns that conform the mining area, and suggest that the evolution of the population experienced two main periods, separated by the First World War and the subsequent mining crisis (1919–1922) [13]. As can be observed in Figure 4, the population increased throughout the first period (especially from 1877 to 1887 and from 1900 to 1910, but showing a stagnation between 1887 and 1900, and exhibited a decreasing trend from 1910, with the exception of the 1920s, when we can observe a slight recovery. The authors who consider Riotinto, Nerva, Zalamea la Real, and Berrocal as the mining area obtained similar results [76].

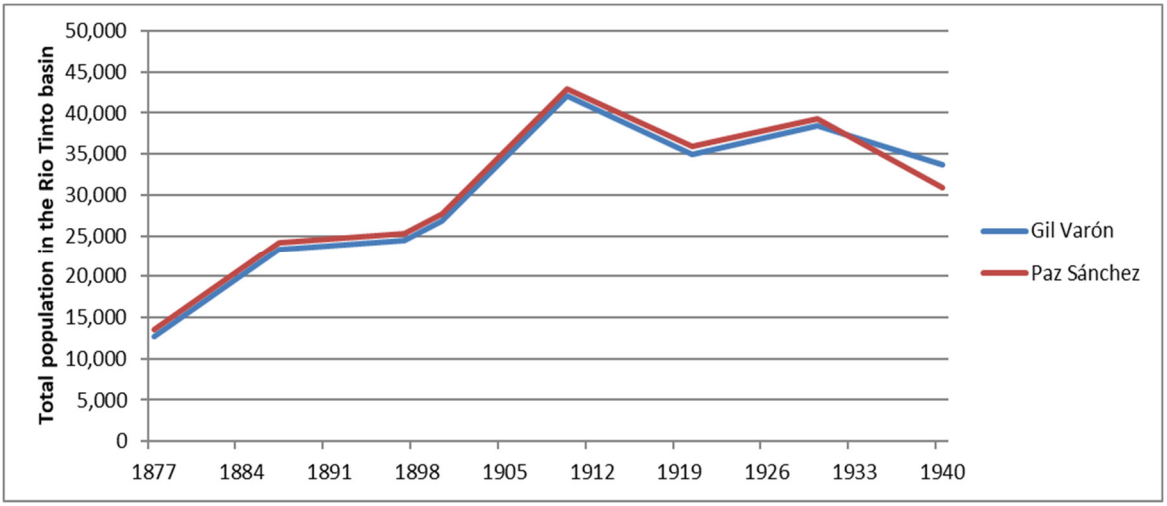

Figure 4. Total population of the Rio Tinto basin (1877–1940). Own elaboration based on [13, 76], and Instituto Nacional de Estadística (INE). Available at: https://www.ine.es/inebase_historia/inebase_historia.htm.

Other works have studied the mortality in the area, exploring the main causes of death in both men and women. The total mortality rates in the period 1873–1899 exceeded 30‰ and reached 40‰ in this six-year period, and even 50‰ in three of these years (1877, 1882, and 1890). In the same way, the child mortality rates were higher than 200‰ in the eight years between 1876 and 1900 [18].

Figure 5 shows the infant mortality rates in Riotinto and Alcoy, another Spanish industrial town. These towns have similar characteristics: rural towns developing an important economic growth in the last third of the nineteenth century due to the Industrial Revolution. While Riotinto was specialised in mining, Alcoy had an important textile industry, specialised in wool textiles.

INFANT MORTALITY RATES (‰)		
Year	**Riotinto**	**Alcoy**
1876	263	169
1877	263	169
1881	290	162
1882	332	161
1883	220	159
1884	230	157
1890	278	147
1893	212	145

Figure 5. Infant mortality rates in Riotinto and Alcoy. Sources: For Riotinto [18]. For Alcoy: Own elaboration using data from historical official censuses, available at INEbase/Historia. Instituto Nacional de Estadística. Available at: https://www.ine.es/inebase_historia/inebase_historia.htm.

Data from Riotinto and Alcoy suggest that the mining activity that was taking place in the first town was considerably more pollutant than the textile production in the second, which was grievously affecting the health of the population.

When considering the causes of death, the most prominent were epidemic diseases (measles, smallpox, and diphtheria), tuberculosis, cardiovascular accidents (men and women), trauma (in men), and enteritis, enterocolitis, and gastroenteritis (in children). The leading cause of death was respiratory disease, accounting for 12.7% of total deaths in Riotinto, and 18.6% of the miners' deaths. The data suggest a clear distinction between the period 1873–1881, the period 1882–1890, and 1891–1900 in the main causes of death in the Riotinto area. In the first years of British exploitation, male deaths caused by respiratory diseases (coughing fits, pneumonia, pleural-pneumonia, bronchopneumonia, bronchitis, lung congestion, asthma, and pneumonitis) were more abundant, especially in those aged 40 to 49 years old, that is, men of working age who had been working in the mines since they were teenagers. From 1873 to 1881 the deaths of women between the ages of 20 and 29 due to respiratory causes doubled with respect to the rest of the intervals. This is an interesting result because women in their 20s were those who were working in the RTCL (after this age interval, they used to marry, and many of them left their jobs in the Company). In the second sub-period (1882–1890), the respiratory deaths in men increased in all the age intervals, maybe because the exposure to sulphurous gases after many years of mining exploitation had affected all of them. Similarly to men, in the case of women, the respiratory deaths increased in all the age intervals after the age of twenty, whereas tuberculosis was the main cause of death until this age. In the last sub-period analysed in this study (1891–1900), the death of young men (until the age of 30) caused by respiratory diseases decreased and rose slightly from this age. This could be explained by the reduction in the use of "*telares*" after the initial years of the 1890s, so the young workers were not so exposed to the sulphurous gases. In this decade, women over the age of twenty experienced an increase of the deaths caused by respiratory diseases.

Considering both of these indicators, the height of the conscripts and the mortality rates, the data suggest that there was a deterioration in welfare in this mining area during the last third of the nineteenth century, coinciding with the intensification of the copper exploitation of the mines by the RTCL, which can be considered as a case of "urban penalty". This term was initially used to define the urban excess mortality rates during the Industrial Revolution [77], and, later, it was used in the field of anthropometry to refer to the decrease in urban physical stature with respect to that of rural areas during this period [78]. Housing problems, insufficient urban infrastructures, and labour conditions contributed to the welfare deterioration together with environmental problems.

4. The Intervention of the Public Sector

Anthropometric and demographic data suggest that the booming mining town of Riotinto suffered an urban penalty phenomenon during industrialisation, provoking social, technological, and scientific reactions and different effects on welfare. The public health response to the problems caused by the industrialisation process is known as "health reform", and was implemented from the mid-nineteenth century across the regions and cities that were experiencing these problems [79]. The origins of the health reform lie in the hygienist movement that appeared in Western Europe in the first decades of the nineteenth century [80]. The hygienist movement emerged in Great Britain and was formed by doctors, architects, and social reformers [81–83]. Hygienists proposed, among several other measures, street paving, waste collection, vaccination, child welfare clinics (in Spain, called *Gota de Leche*), and outreach campaigns about nutrition, childcare, and personal and domestic hygiene. From the 1830s, this movement called on central and local authorities to fight urban excess mortality rates by implementing health measures to prevent uncleanliness and airborne miasmas: sewage systems, cheap housing, and the regulation of urbanisation and construction, among other factors. Although the miasma theory was proven to be false (and was replaced by the bacteriological theory in the 1880s), these measures and bromatology reduced the risk of contracting infectious diseases [84,85]. From the 1870s, hygienists, republicans, socialists, and anarchists demanded that public authorities implement health reforms in Spanish towns [86].

In order to study public intervention in the copper mining area of Riotinto, we link the mortality and anthropometric indicators to local government spending on health reform during a period of extraordinary demographic growth due to the expansion of mining in this area of south-west Spain (last third of the nineteenth century and first decade of the twentieth).

Based on Nerva's local government budget settlement, first, we reconstructed the total amount budgeted by the municipality (representing the intentions of the politicians governing the town in each year) and the total expenditure (the final expenses and investments made by the town council, representing the reality). The data were reconstructed from archival documents conserved in the Municipal Archive of Nerva. Total expenditures were divided by the total population in Nerva to obtain the expenses per capita. Note that all the data used (in pesetas) have been deflated using the consumer price index proposed for Spain (real 1913 pesetas) [87]. Our methodology differentiates the quantities budgeted by the municipality and the real expenses made each year. The first would suggest the political intentions, and the second would show the real effort made by the local authorities [88]. This reconstruction would include virtually all of the actions made by the public sector in this area, because the health and educational responsibilities in Spain were conferred to the municipalities during this period [89]. The RTCL made a paternalistic attempt to offer some health services, particularly to care for those injured in work accidents, but the workers preferred the public service to evade the control of the company.

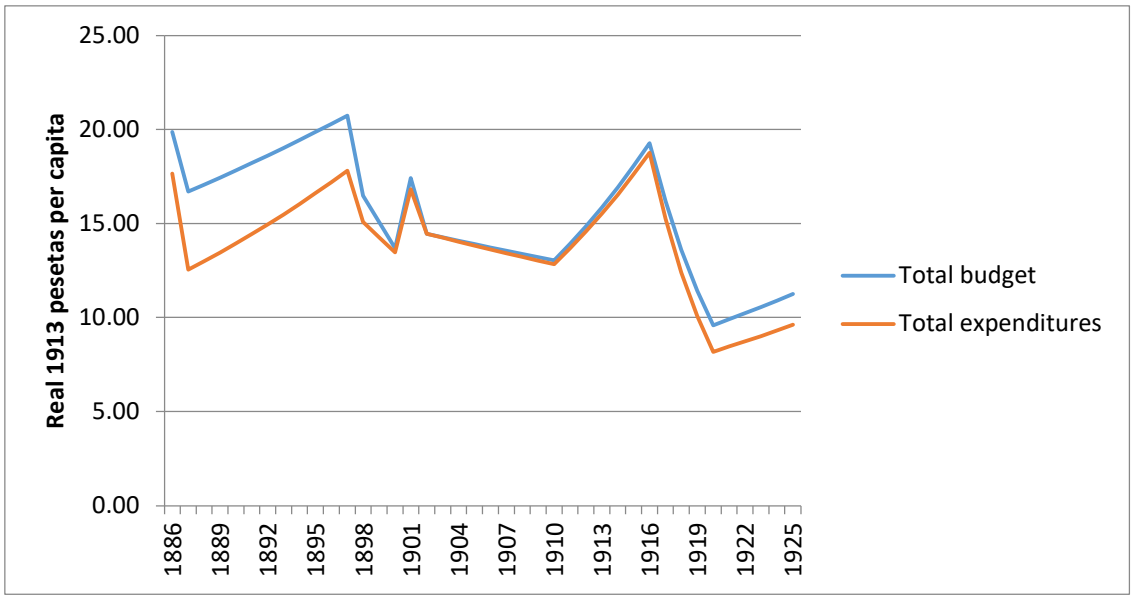

Figure 6. Total budget settlements per capita and total expenditures in Nerva (1886–1925). Source: Archival records from the Municipal Archive of Nerva.

Figure 6 shows the increase not only in the budget, but in the final expenditures in Nerva during the second half of the 1880s and the first half of the 1890s, probably due to the increasing necessities of a town experiencing a consolidation process with considerable population growth. This trend changed dramatically after 1896–1897, when the budget and the expenditures decreased until 1910. In the years previous to the First World War, the town council increased the municipal budget and the expenditures, which fell during the war years and the post-war. From the 1920s onwards, there was a slight rise until 1925 (the last year analysed in this study). In the next step, we selected and quantified the expenditure on health reform in Nerva according to the items of the 1886–1925 annual budgets [90,91]. It consisted of healthcare (charity, doctors, matrons, and a hospital), preventive public health measures (water, sewage systems, sanitation, trees, food markets, slaughterhouses, cemeteries), and other health-related expenditures (urban planning studies, fire department, architects, fountains and water and pipe works, street maintenance, and staff wages). The results obtained can be observed in Figure 7.

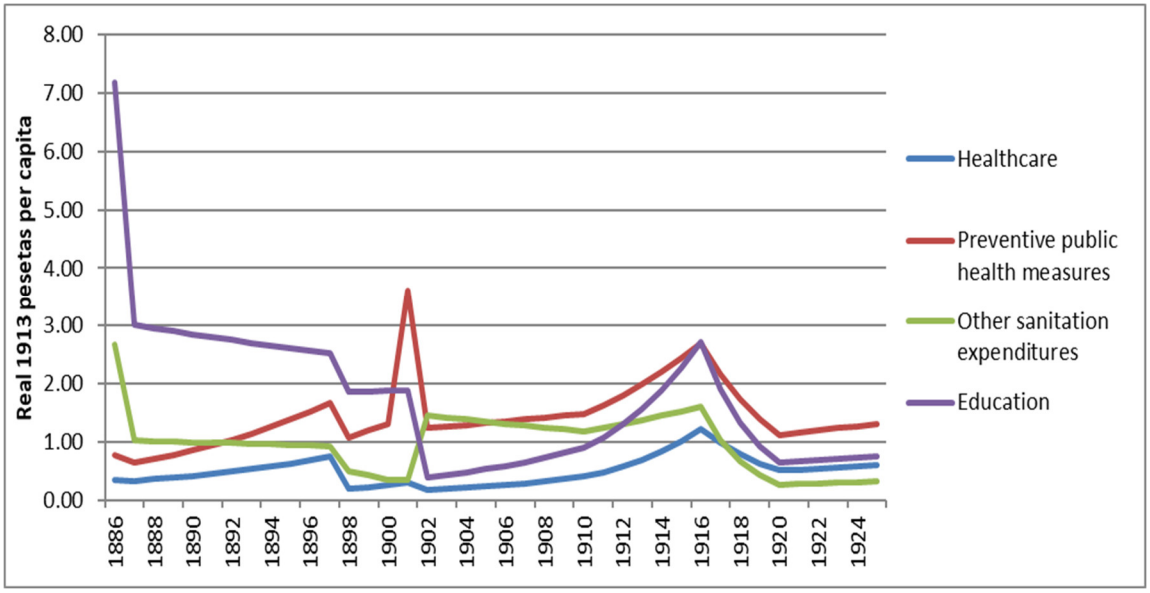

Figure 7. Per capita expenditures on health reform in Nerva (1886–1925). Source: Archival records from the Municipal Archive of Nerva.

Figure 6 suggests that the evolution of the four expenditure groups was very similar throughout the period. Indeed, the data show a relatively stable trend between 1886 and 1925, but we can find some sub-periods. The first would begin in 1886, the year in which Nerva, after becoming an independent town, elaborated its first own municipal budget, which was also its last until the final years of the nineteenth century. Here, the trend was decreasing in education and other health-related expenditures, and increasing in preventive public health measures. Healthcare stagnated during this sub-period. The second sub-period ran from 1900 to 1914, when all kinds of expenditures rose except education (the central government assumed the education expenditures in Spain through the Royal Decree of 26th October, 1901). The third sub-period, beginning in the years of the World War, showed a decreasing trend, although it seemed to recover after 1920, when the post-war period finished.

Considering the aggregated sanitary reform expenditures per capita (red line in Figure 7), Nerva shows the typical evolution of a mining town experiencing a "boom", with a high initial investment in some basic infrastructures (in the case of Nerva, especially in the construction of the school building, and in the design and construction of streets) and a drop and stagnation of the expenditures and investments in the following years after the emergence of the mining settlement, with a low level of expenditure on public services. After the settlement became consolidated, there was a third phase in which the expenditures rose, especially due to the investment in para-sanitary services and infrastructures such as fountains, water-pipes, cemeteries, and the sewage system. In the fourth phase, these investments and expenditures mostly fell again.

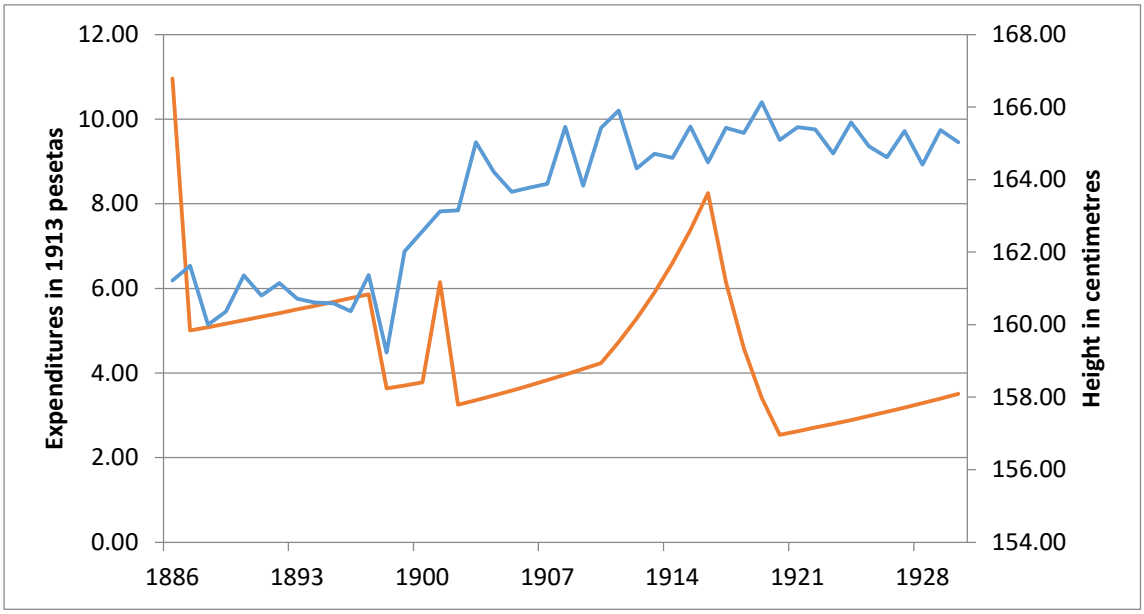

Figure 8. Real sanitary expenditures per capita and height in the Riotinto area (1885–1930). Sources: Real sanitary expenditures per capita (red line): Archival records from the Municipal Archive of Nerva. Average height of recruits (blue line): Courtesy of Miguel Ángel Pérez de Perceval Verde and Ángel Pascual Martínez-Soto (University of Murcia, Spain).

Our last goal is to check the effectiveness of the public sector´s intervention in the welfare of the population of this copper mining area. To do this, we compared the evolution of the real expenditures on health per capita (red line in Figure 8), including the four groups of expenses (healthcare, preventive public health measures, other health-related expenditures, and education expenses) and the evolution of the average height of the conscripts throughout the period of study (blue line in Figure 8), an accepted welfare indicator, as explained above. As observed in the last figure, the comparison suggests a stagnation of expenditures and height between 1886 and 1896, a drop until 1898, and a recovery of both indicators in the period 1899–1914. After the World War, we can see a stagnation in height and a fall, followed by a slight rise in health expenditures.

Our interpretation is that the data suggest a positive correlation between the two indicators, especially in the rising sub-periods, which was particularly the case in 1886–1898 and in 1899–1914. In these periods, the negative external effects (also defined in the economic theory as market failures) caused by the copper exploitation (not only due to the heap roasting, but to the exploitation in general) in Riotinto began to be mitigated by the efforts made by the municipality in the implementation of a health policy that can be linked to the health reform process that took place in other industrial regions across Europe during the second half of the nineteenth century and the first third of the twentieth century.

5. Conclusions

The "Year of Shots" (February 4th, 1888) is considered as an early landmark of Political Ecology [92]. This pacific demonstration demanding improvements in working conditions and the reduction of the copper fumes from the "*teleras*" ended in a massacre, probably with more than two hundred deaths. The responsibilities were never elucidated. Moreover, the intense and biased pressures of the RTLC on the government were successful. The demonstration was the culmination of a long conflict regarding, fundamentally, the deleterious effects of copper fumes on plants and health. The publication of the "*Reglamento Provisional para la indemnización de los daños y perjuicios causados a la agricultura por las industrias mineras*" (1890) recognised the "harmonised solution" defended by the Company. This legal measure focused on the organisation of a public system of mediation based on the payment of compensations to the owners concerned. At the same time, the report of the Royal

Academy of Medicine certified the innocuous nature of the smoke. Therefore, the final result of this conflict seemed a clear victory for the company [8,33,34].

However, the "smoke question" had a very negative impact on its relations with the mining communities [93]. It is not surprising that, from the last decade of the nineteenth century, the company developed a paternalistic role concerning, especially, health services to improve the welfare of its employees and to avoid government intervention. The RTCL provided several pharmaceutical and hospital services, including treatment for respiratory diseases, to be discounted from the workers' wages [51]. However, some workers tended to distrust the Company because, in practice, the Health Department defended the interests of the firm in detriment to those of the workers´ health [51]. For this reason, some unionists, such as Egocheaga, tried to organise, without success, mutual associations. Despite this, as a former physician of the RTLC, A. MacKay, remarked that the aim was to build a healthy community at the forefront of the world's mining basins [94]. His idealistic opinion was far removed from reality. Taking into account the biological indicators or the intervention of the public sector from a local point of view (the town of Nerva, in the heart of the mining community), our work suggests, first, that the height of the conscripts declined, especially during the mining boom decades; second, that the mortality rates continued being abnormally high and linked to respiratory diseases; and, finally, that the municipal budgets, and specifically health expenditures, experienced a notable increase during the first years of the twentieth century (until 1914).

All of this evidence, especially the heights and the health expenses, show the typical evolution of a mining town, which seems to suggest that attempts were made to mitigate the negative effects of the mining exploitation using health policies to combat this kind of urban penalty.

The environmental problems caused by the hydro-metallurgy activity of the RTCL in watercourses and fisheries provoked considerably less social contestation than air pollution, so we have not paid so much attention to this. Several researchers have recently studied the soil and waters of Rio Tinto and Odiel, taking stock of this pollution [95,96], so a future line of research should assess the consequences of water pollution on the health and welfare of the population in this area. Another line of research in the future is the study of inequality in the effects of environmental damages; in other words, how pollution had different consequences on health depending on the socio-economic status and other variables. Finally, climate change as a factor that had influence on the environment and the welfare in the long term constitutes another line of future research [97,98].

Finally, the answer to the smoke problem of the RTCL could be considered, at least in two senses, as a precedent of current corporate sustainability. From an environmental perspective, the atmospheric pollution conflict in Huelva was already a "global" problem, and the influence of the strategies of the American companies to abate pollution constitutes a piece of evidence in this respect [8]. The American mining conservation movement was based on two main ideas: the awareness of the exhaustion of mining resources and the need to promote processes in order to reduce mining waste [99]. Basically, this was a case of an inefficient exploitation of resources. The only solution was scientific and technical. The mining companies were responsible for their implementation, especially those related to atmospheric pollution [34,36,100]. This type of strategy had a real and long-term influence in the mining sector. Thus, the research on Pollution Prevention and Eco-efficiency Strategies, based on the relationship between efficiency and pollution, was the new approach of the industry to Sustainable Development (SD) from the 1990s [101–104].

From a social perspective, smelter smoke seriously affected the community's and workers´ health and gave rise to an intense debate. This scientific controversy provided the foundation for the institutional and technical measures implemented to address the problem [105]. As previously mentioned, from 1888, the RTLC reorganised the Health Department in order, apparently, to improve the wellbeing of the workers. However, after the massacre, the Company really wanted to avoid regulation and to fully control the mining community´s health. This medical and pharmaceutical service is a key piece of the paternalist programme [12]. Today, mining companies feel that the old paternalism could have promoted an undesirable and "unhealthy dependent relationship" with the community [106]. Mining sustainability, from the point of view of the

industry, required new principles and practices, and implies special attention to occupational health, safety police, and medical services [107]. More specifically, the first contribution (of three) of the mining sector to SD is to improve health, wellbeing, and quality of life. Corporate Social Responsibility (CSR) is the perfect tool to achieve this objective [108]. Significantly, a study about the Rio Tinto Group, the successor firm of the RTCL, shows that its CSR agenda is focused (among other elements) on services traditionally provided by the governments of developing countries, as providers of health services [109].

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