

# Environmental and Medical Aspects Related to the Sixth Plague of Egypt

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## ABSTRACT

The sixth Egyptian plague described in the Book of Exodus (the second book of the Pentateuch or Torah) was one of the Ten Plagues of Egypt which occurred probably during the 13<sup>th</sup> century BC. This plague was an acute epidemic skin disease characterized by boils that eventually formed ulcers on the skin. The sixth Egyptian plague comprises the first medical report on the harmful effects of soot/dust on skin and presages the nowadays well-known harmful effects of soot-induced air pollution on the environment and human health.

**Keywords:** anthrax, boils, *Book of Exodus*, environmental medicine, *Old Testament*, soot, sixth plague.

## INTRODUCTION

The Sixth Plague was one of the Ten Plagues of Egypt (also known as the Ten Plagues, the Plagues of Egypt, or the Biblical Plagues). These ten disasters, described in the *Book of Exodus*, the second book of the *Pentateuch* or *Torah*, were sent upon Egypt by God to convince the Pharaoh to free the Israelite slaves from the bondage and oppression they had endured during their stay in Egypt for 430 years (see Exodus 12:41; Galatians 3:17; Acts 13:17). The Ten Plagues of Egypt pro-

bably occurred during the 13<sup>th</sup> century BC. According to the biblical text, “then the LORD said to Moses and Aaron: ‘Take for yourselves handfuls of soot from a kiln, and let Moses throw it toward the sky in the sight of Pharaoh. It will become fine dust over all the land of Egypt, and will become boils breaking out with sores on man and beast through all the land of Egypt’. So they took soot from a kiln, and stood before Pharaoh; and Moses threw it toward the sky, and it became boils breaking out with sores on man and beast. The magicians could not stand before Moses because of the boils that were on them and on all

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FIGURE 1. Skin lesions caused by anthrax (13)

the Egyptians" (Exodus 9:8-11). The sixth plague was more personal than the previous plagues. Soot was the black particulate matter formed as a by-product of wood combustion in the Egyptian kilns. In the Greek Bible translation (known as "Septuagint"), the phrases "soot from a kiln", "fine dust" and "boils breaking out with sores" are expressed as "αἰθάλη καμιναία", "κονιορτός" and "ἔλκη, φλυκτίδες ἀναζέουσαι", respectively. The word "αἰθάλη" derives from the ancient Greek verb "αἶθω" which means "burn". Thus, the Egyptians, who had put the Israelites to work in kilns under oppressive conditions (see Exodus 1:8-14; 5:7-19), were then punished with the soot from the kilns.

It is obvious that the details given in the *Pentateuch* or *Torah* about the sixth plague, which struck the Egyptians and their animals (see Exodus 9:8-11; cf. Deuteronomy 28:27.35.59-60), are insufficient for its identification. According to the biblical text, the harmful effects of soot on the skin of the Egyptian people and animals occurred after its dispersal into the air by Moses and the creation of fine dust. The sixth plague was an acute epidemic skin disease, though probably not deadly, characterized by boils that eventually formed ulcers on the skin. The Egyptians and their animals were most likely exposed to fine dust with soot from kilns not only *via* the skin, but also *via* inhalation. Yet, the biblical text does not mention respiratory health problems among the Egyptians after their exposure to soot/dust, but only skin lesions. Although several theories (e.g., Hort's theory or "ecological domino theory") and assumptions (e.g. skin anthrax, a form of leprosy, smallpox, infectious boils carried by the stable fly) have been made to determine this

epidemic skin disease (1-10), none of these associate this plague directly with the described causative agent of biblical text: the fine dust with soot from kilns. According to the Commission Recommendation of 19 September 2003 concerning the European schedule of occupational diseases (notified under document number C[2003] 3297), soot is an occupational cause of irritant contact dermatitis (ICD) or allergic contact dermatitis (ACD) (acute exposure) and skin cancer (chronic exposure) (Annex 1, 201.01) as well as a suspected occupational cause of broncho-pulmonary ailments and cancers (chronic exposure) (Annex 2, 2.303) (11). Moreover, dust particles (see Exodus 9:9) have a larger diameter (diameter less than 10 micrometers; Particulate Matter/PM-10) than soot particles (PM-2.5) and hence, have less penetrance into the lungs. All the above could explain the absence of respiratory problems among the Egyptians after their exposure to dust, and support (not adequately because of the epidemic character of skin disease) the hypothesis of an *airborne contact dermatitis* (responsible for ICD or ACD) (12) as a possible cause of the sixth plague. Considering the described skin lesions (boils) of the Egyptians that eventually formed painless sores (ulcers, eschars), we can accept that the acute and epidemic form of the sixth plague could be an *infectious dermatitis* caused by microbial agents (such as *Staphylococcus* spp. or *Bacillus anthracis*). However, taking into consideration the pathophysiology and the skin lesions (Figure 1) of cutaneous anthrax (13), if we accept the medical hypothesis of skin anthrax, we must view that *Bacillus anthracis* probably came from the Egyptians' dead animals (fifth plague) (10, 14) or dead frogs (second plague)

and was transmitted to the Egyptians and their animals through the bites of infected mosquitoes (third plague) or flies (fourth plague) (4). But accepting this theory is like agreeing that the author of the *Book of Exodus* devised soot from the kilns and its spread in the environment in order to justify the clinical picture of skin disease and its epidemic character. It is noteworthy that the name anthrax is derived from the Greek word “ἄνθραξ” which means coal, because black skin lesions like coal (black eschars) are formed in the cutaneous form of anthrax (10).

Regardless of theories and hypotheses about the cause of the sixth plague, the boils resulting from soot/dust comprise the first medical report on the harmful effects of soot on skin. Many centuries later (18<sup>th</sup> century AD), an English surgeon, *Percivall Pott* (1714-1788 AD), hypothesized that chronic exposure to soot in London chimney sweeps was associated with an increased risk of developing cancer of the scrotum (a squamous cell carcinoma of skin) (15, 16). This was the first occupational link to cancer, and Pott was the first person to demonstrate that a malignancy could be caused by an environmental carcinogen, soot (17). Since then, many studies have confirmed that chimney sweeps have an increased risk of scrotal and other skin cancers. Studies of chimney sweeps in several European countries have also found associations with other cancers, including lung, esophageal, and bladder cancers (18, 19). We should note that since the industrial revolution, soot has been formed as a by-product of combustion or pyrolysis not only from wood (as in the Egyptians’ kilns) or coal, but also other organic (carbon-containing) materials such as fuel oil, waste oil, paper, plastics, and household refuse. Therefore, the chemical compositions and properties of soot are highly variable and depend on the type of starting material and combustion conditions (19). Humans may be exposed to soot by inhalation, ingestion, or dermal contact (19). The general population is potentially exposed to soot from fireplaces, furnaces, engine exhaust, and particulate emissions from any combustion source (19). Occupational exposure to soot may occur among chimney sweeps, heating-unit service personnel, brick masons and helpers, building demolition personnel, insulators, firefighters, metallurgical workers, horticulturists, and anyone who works where organic materials

are burned (19). The carcinogenicity of soot is due to a number of known and potentially carcinogenic chemicals which it contains, such as arsenic, cadmium, chromium, nickel, and several polycyclic aromatic hydrocarbons (PAHs), including benz[a]anthracene, benzo[a]pyrene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene (11). The acute action of soot as a cause of ICD or ACD is already prementioned. We highlight that what makes the soot dangerous for human health is the combination of its extremely small size (2.5 micrometers or smaller in diameter; PM-2.5) and its toxic composition.

Moreover, this plague derived from soot/dust centuries before is an indicator of what is known today as a pollutant which is dangerous for the environment and human health. An example of fatal soot-induced air pollution is the classical or sulfurous (“London-type”) smog (“smog” refers to a mix of pollutants [smoke] and environmental factors [fog]) which is caused by the combustion of solid fuels, especially coal and wood in combination with a relatively low temperature and high relative humidity; the smoke of classical smog consists of a mixture of soot particles with sulfur dioxide. The Great Smog of 1952, which affected the British capital London in December 1952 and killed 12,000 people, was a severe air pollution (classical smog) event (20). We note here that at that time the fireplaces in London burned mineral coal. Most of the deaths in London were caused by respiratory tract infections from hypoxia and by a mechanical obstruction of the air passages by pus arising from lung infections caused by the smog (21, 22). The lung infections were mainly bronchopneumonia or acute purulent bronchitis superimposed upon chronic bronchitis (21). Nonetheless, air pollution from classical smog is a very old phenomenon (23, 24). For example, in the *Book of Genesis*, after the destruction of Sodom and Gomorrah, Abraham “looked down toward Sodom and Gomorrah, and toward all the land of the valley, and he saw, and behold, the smoke of the land ascended like the smoke of a furnace” (Genesis 19:28). Also, the ancient Roman philosopher *Seneca* (c. 4 BC -AD 65) in a letter to *Lucilius* (Letter 104) wrote the following: “As soon as I escaped from the oppressive atmosphere of the city, and from that awful odour of reeking kitchens which, when in use, pour forth a ruinous mess of steam and soot,

I perceived at once that my health was mending" (24, 25).

In conclusion, the sixth Egyptian plague, as described in the *Book of Exodus*, constitutes the earliest medical report on the detrimental impact of soot/dust upon the human health and the

environment, which is now well-known, having been documented over time since then. □

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