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Editorial

Max von Pettenkofer Award

In August 1892, a cholera outbreak struck Hamburg. In just a few months, 17 000 cases of the illness were recorded resulting in 8600 deaths within a population of about 640 000 (Evans, 1987). At its peak intensity, only a few weeks after the onset, a thousand illnesses and five hundred deaths were reported daily in the city. Intense but short-lived cholera outbreaks had struck Hamburg and other European cities repeatedly through the nineteenth century. The 1892 episode was Hamburg's most severe in terms of lives lost (Evans, 1987). It was to be the last major cholera outbreak in Western Europe.

Cholera acts ferociously. After a short incubation period, 'symptoms are generally abrupt and include watery diarrhoea and vomiting. … In adults with severe cholera, the rate of diarrhoea may quickly reach 500–1000 ml/h, leading to severe dehydration. … The fluid loss may be so rapid that the patient is at risk of death within a few hours after onset, and most deaths occur during the first day' (Sack et al., 2004).

Cholera has been brought under effective control in the more developed countries owing to good sanitation and water treatment practices. Improved case management relying on oral and intravenous rehydration treatment has markedly reduced cholera-associated mortality rates in less developed countries (Sack et al., 2004). Nevertheless, cholera remains a major global health issue with an estimated annual incidence rate of 3-5 million cases resulting 100 000–120 000 deaths (Ali et al., 2012).

In the late 1800s, scientific controversy raged over the causes and control of cholera. At the heart of the conflict were two prominent German scientists, Robert Koch (1843–1910) and Max von Pettenkofer (1818–1901). Koch's contagionist view of the disease focused on its microbial cause. In February 1884, Koch reported from Calcutta (where cholera is endemic): he had isolated and identified the bacterium 'found in the intestines and stools of cholera victims [that] was the causal agent of the disease' (Howard-Jones, 1984). According to Koch, ingestion of this bacterium was both necessary and sufficient to cause cholera. Effective management of outbreaks necessitated measures such as isolation, quarantine, and disinfection.

Koch's discovery was celebrated in Berlin as a matter of pride for the German empire. However, his influence was not large in Hamburg, a city-state that still had considerable independence (Evans, 1987).

It also happens that Robert Koch was not the first to identify *Vibrio cholerae* as the bacteriological cause of cholera. The credit for that discovery, which had occurred 30 years before Koch's achievement, belongs to Filippo Pacini of Florence (Bentivoglio and Pacini, 1995; Howard-Jones, 1984). Pacini's achievement was not widely known in Europe in the late nineteenth century.

Max Von Pettenkofer had devoted much of his prolific research career to the study of cholera. He dismissed the view that, 'cholera is simply an infectious or contagious disease, passing from the sick and their excreta to the healthy' (Von Pettenkofer, 1892). Von Pettenkofer argued that the contagionist's view 'does not satisfy the epidemiologist; for the latter knows that there are not only cholera-immune people, but also cholera-immune places, and that even in places where cholera has prevailed there are seasons when it will not spread, although introduced.' Von Pettenkofer's complex theory of cholera causation is well summarized by Morabia (2007). Cholera results 'from the interaction between a postulated cholera germ and the characteristics of soils. In order to cause cholera, the cholera germ had to become a cholera miasma, but this transformation required prolonged contact of the germ with dry and porous soils when groundwater levels were low. … Von Pettenkofer's postulate also implied that cholera-patient quarantine or water filtration was useless to prevent and/or control cholera epidemics.'

Max von Pettenkofer (Figure 1) was of a generation older than Koch. He completed his university studies in pharmacy and medicine in 1843. He worked under renowned chemist, Justus von Liebig, at the University of Giessen. Pettenkofer was appointed to a professorship in medical chemistry at the University of Munich in 1847. In the second half of the nineteenth century, he was a highly influential scholar. He became the first chaired Professor of Hygiene at the University of Munich in 1865. 'In 1879, the Hygienic Institute, which had been built for him, opened in Munich' (Trout, 1977). Von Pettenkofer co-founded two successful journals: *Zeitschrift für Biologie* (first published in 1865) and *Archiv für Hygiene* (first published in 1883).

In Hamburg in 1892, hygienic practices were more aligned with von Pettenkofer's views than with Koch's

Fig. 1 Max Von Pettenkofer (1818–1901). (Image reproduced from http://en.wikisource.org/wiki/Popular_Science_Monthly/Volume_23/October_1883/Sketch_of_Dr._Max_von_Pettenkofer.)

(Evans, 1987). The city had a sewerage system to collect human waste and thereby protect the soil from contamination. These wastes were discharged directly, without treatment, into the Elbe River. The flood tide could sweep the effluent upstream, especially when the river level was low as during periods of drought (Anon, 1893). The drinking water supply system took water from the Elbe River above Hamburg. This water was stored in reservoirs for distribution, but was not otherwise treated. The configuration provided for the rapid spread of the disease in the 1892 outbreak, 'teaching a lesson which could no longer be misunderstood' (Reincke, 1904). Sand filtration was added to the water supply system shortly thereafter.

In 1892, Max von Pettenkofer was approaching the end of a long career. He retired from active work only a few years later. Although his theory of causation for cholera evolved over the decades that he had worked on the issue, it does not appear that he ever changed his core views. As interpreted by Morabia (2007), 'The disastrous consequences of the lack of water filtration during the massive outbreak of cholera in … Hamburg in 1892 tarnished von Pettenkofer's reputation and marked thereafter the course of his life. Von Pettenkofer's complex mode of thinking sank into oblivion even though, in hindsight, germ-environment interactions are more appropriate than is bacteriology alone for explaining the occurrence of cholera epidemics in populations.'

From the perspectives of hygiene generally and indoor environmental quality and health specifically, it is regrettable that von Pettenkofer's scientific achievements have been obscured by his cholera-associated infamy. Broad discussions of his achievements can be found in remembrances (Evans, 1973; Locher, 2001; Trout, 1977). Von Pettenkofer made several seminal contributions to the indoor air sciences before there was wide understanding that science could play any role in improving indoor environmental quality and health. To honor these contributions, in the late 1990s, the International Academy of Indoor Air Sciences (now known as the Academy of Fellows of the International Society of Indoor Air Quality and Climate, ISIAQ) established the Max von Pettenkofer Award. It is the society's highest award, granted to an individual in recognition of outstanding work in advancing the indoor air sciences.

To provide some sense of his advanced understanding and insight, here are highlights of three of von Pettenkofer's contributions to the indoor air sciences.

- Chamber studies of indoor emission sources (Pettenkofer, 1862). Source characterization is of central importance to studies of indoor air pollution. One key tool is the environmental chamber. With controlled ventilation, temperature and humidity, the emitting source or activity is allowed to release pollutants within the chamber. Concentrations are measured and emission rates are computed from material conservation. For his 1862 report in *The Lancet*, Pettenkofer motivates his investigation and summarizes his goals by noting that 'substances which pass off from the skin and lungs require as close an investigation as those that are eliminated by the urine. Hitherto no method has been devised, or apparatus constructed, adequate to the conditions of such an inquiry. … The present state of physiology requires conditions of inquiry in which a man can breathe and move freely without any apparatus attached to his body… This can only be done by placing the man in an accurately measurable current of air, which can be tested for certain constituents before it comes in contact with him, and can be investigated again after the air has taken up the gaseous matters thrown off by the skin and lungs.'
- Importance of source control as the first approach to ensuring good indoor air quality (Von Pettenkofer, 1873). It's a critical lesson and one that we seem to have to relearn at regular intervals. For pollutants that have indoor emission sources, control should be applied at the source, rather than through ventilation or air cleaning. In recent decades, this conclusion has been reaffirmed for indoor radon, environmental tobacco smoke, and volatile organic compounds, among other pollutants. Pettenkofer expressed the idea early and with great clarity, writing 'If I had a nuisance in my room, I should be a fool if I kept it there and trusted to stronger ventilation. The rational way is to do away with the pollutions, not to keep them and to fight them by ventilation.'

- Ventilation requirements for controlling human bioeffluents (Von Pettenkofer, 1873). This contribution might be Max von Pettenkofer's most impressive to the indoor air sciences. The following quote summarizes his seminal understanding about the significance of human bioeffluents, the use of carbon dioxide (called carbonic acid here) as an indicator species, and the level of ventilation required for control. Note that 2100 cubic feet per person per hour corresponds to 16.5 l/s per person, close to the value prescribed in today's ventilation standards. The carbon dioxide abundance of 1000 parts per million is also consistent with current understanding of the value that marks the threshold of significantly degraded air by human bioeffluents. To carry out these studies, von Pettenkofer devised an accurate analytical method for measuring carbon dioxide in air based on acid–base titration (Pettenkofer, 1858). He wrote, 'We deteriorate the air of a closed space inevitably by using it for the maintenance of our respiration and perspiration. To which degree, then, may we alter or pollute by our own emanations the air of a closed space, without going so far as to injure our health? … What standard have we for measuring the deterioration of the air? … I started from the excretion of carbonic acid, as it takes place from the living human body; its quantity in the air can be ascertained easily and accurately. There is some in the open air, although very little; the question was, therefore, to find out its increase in a number of inhabited rooms, with notoriously good and notoriously bad air, and to draw a comparison. … I will not say that I consider the detected carbonic acid as the principal drawback to such air; it is, in my mind, the measure only for all the other alterations which take place in the air simultaneously and proportionately, in consequence of respiration and perspiration; its increase shows to what degree the existing air has been already in the lungs of the persons present. … A series of examinations resulted in the conviction that one volume of carbonic acid in 1000 volumes of room air indicates the limits, which divide good from bad air. … On an average, in spaces in which the air kept good, there existed a ventilation of more than 2100 cubic feet per head and hour.'

Table 1 Recipients of the Max von Pettenkofer Award

Recipient	Year
Thomas Lindvall	1999
Bernd Seifert	2002
P Ole Fanger	2005
John Spengler	2008
Jan Sundell	2011

The ISIAQ Academy of Fellows selects a recipient of the Max von Pettenkofer Award to be presented at each of the international Indoor Air conferences. The previous five winners (Table 1) were all founding members of the International Academy of Indoor Air Sciences. These distinguished professionals have played important roles in giving shape to our research community, in advancing our knowledge of key aspects of the indoor air sciences and in the professional application of scientific knowledge to improve indoor environmental quality and health. Max von Pettenkofer would be proud.

William W Nazaroff
Editor-in-Chief

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