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Am J Ind Med. 2001 Aug;40(2):170-9.

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Health effects among employees in sewage treatment plants: A literature survey.

Thorn J[1], Kerekes E.

Author information

Abstract

BACKGROUND: Over the years, there have been regular reports in the media of work-related symptoms among employees at sewage treatment plants. Concern has spread among employees over the lack of knowledge of risk agents' symptoms, and diseases in that environment. This paper reviews the investigations of health risks in employees working in the sewage treatment plants.

METHODS: A literature search was performed with the search terms; sewage, waste water, health effects, infection, and health hazards. Articles on health effects in relation to sewage were selected.

RESULTS: Work in sewage water plants can involve exposure to different types of microorganisms and chemicals. The bacterial exposure is dominated by bacteria that naturally occur in nature. However, different bacteria and viruses that give rise to infections can be present in this environment and thus there exists a risk of infection, especially of hepatitis A. Investigations suggest that gastrointestinal tract symptoms are more common among employees at sewage treatment plants than among controls. Respiratory symptoms, fatigue, and headache have also been reported in several investigations. The cause of the symptoms is unknown, although certain data suggest that they are caused by inflammation. The results suggest that endotoxin in Gram-negative bacteria may be one of the causative agents. As regards cancer, some studies report an increased risk of stomach cancer and a few studies report an increased risk of cancer in the larynx, liver or, prostate or of leukemia. The spread of the cancers over a multitude of organs does not support a hypothesis of causality with agents commonly found in sewage treatment plants.

CONCLUSIONS: Further investigations are needed to determine the work-related effects and ascertain the causal agents.

PMID: 11494345 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances

Waste Manag. 2009 Aug;29(8):2227-39. doi: 10.1016/j.wasman.2009.03.028. Epub 2009 Apr 28.

2. **A review of waste management practices and their impact on human health.**

Giusti L.

Author information

Abstract

This work reviews (i) the most recent information on waste arisings and waste disposal options in the world, in the European Union (EU), in Organisation for Economic Co-operation and Development (OEDC) countries, and in some developing countries (notably China) and (ii) the potential direct and indirect impact of waste management activities on health. Though the main focus is primarily on municipal solid waste (MSW), exposure to bioaerosols from composting facilities and to pathogens from sewage treatment plants are considered. The reported effects of radioactive waste are also briefly reviewed. Hundreds of epidemiological studies reported on the incidence of a wide range of possible illnesses on employees of waste facilities and on the resident population. The main conclusion of the overall assessment of the literature is that the evidence of adverse health outcomes for the general population living near landfill sites, incinerators, composting facilities and nuclear installations is usually insufficient and inconclusive. There is convincing evidence of a high risk of gastrointestinal problems associated with pathogens originating at sewage treatment plants. In order to improve the quality and usefulness of epidemiological studies applied to populations residing in areas where waste management facilities are located or planned, preference should be given to prospective cohort studies of sufficient statistical power, with access to direct human exposure measurements, and supported by data on health effect biomarkers and susceptibility biomarkers.

PMID: 19401266 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances

Occup Med. 2001 Jan-Mar;16(1):23-38.

3. **Sewage workers: toxic hazards and health effects.**

Mulloy KB.

Author information

Abstract

Municipal sewage workers provide an essential service in the protection of public health.

The wastewater treatment process brings the worker in contact with multiple pathogens, toxic gases, chemicals, and physical hazards. Issues such as the prevalence of hepatitis A among wastewater treatment workers in the U.S. have not been well studied. There remains a controversy on the need to offer hepatitis A pre-exposure immunization. Health effects to some exposures, such as gram-negative bacteria and endotoxins, have been well studied among other workers, and preventive measures, such as permissible endotoxin levels, that have been established for these workers should be adopted for the wastewater treatment environment. Further study into mortality and morbidity rates among sewage workers and the relationship to exposures and the development of preventive measures is needed.

PMID: 11107222 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances

Chemosphere. 2003 Sep;52(9):1373-9.

4. ## Double trouble: health risks of accidental sewage release.

Bridges O.

Author information

Abstract

Occupational health risks from long-term exposure to sewage are well documented [Am J. Ind. Med. 25 (1994) 59; Ann. Agric. Environ. Med. 81 (2001) 39; Am J. Ind. Med. 40 (2001) 170]. Some studies suggest an increase in the incidence of specific cancers [Am J. Ind. Med. 19 (1991) 75; J. Occup. Med. 36 (1994) 31]. There are also many reports of acute fatalities in confined spaces (sewage chambers and pipes) [H&S at Work 13 (1991), 10; FACE report: sewer worker dies when inflatable sewer plug bursts in Washington, DC, Performer, National Institute For Occupational Safety and Health, 19th July 1990]. In a residential area incidents of sudden sewage release can be regarded as double trouble because both the emergency service personnel and the local residents may be exposed to a galaxy of chemical and microbiological agents present in sewage. However, data on the effects of acute non-occupational exposure due to accidental sewage releases is still very limited. The incidents investigated here took place at two different locations in the southern part of the UK. In both incidents the symptoms experienced by those exposed were more serious than expected by the public health experts.

PMID: 12867166 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances

Crit Rev Microbiol. 2002;28(4):371-409.

5. **Microbial agents associated with waterborne diseases.**

Leclerc H[1], Schwartzbrod L, Dei-Cas E.

Author information

Abstract

Many classes of pathogens excreted in feces are able to initiate waterborne infections. There are bacterial pathogens, including enteric and aquatic bacteria, enteric viruses, and enteric protozoa, which are strongly resistant in the water environment and to most disinfectants. The infection dose of viral and protozoan agents is lower than bacteria, in the range of one to ten infectious units or oocysts. Waterborne outbreaks of bacterial origin (particularly typhoid fever) in the developing countries have declined dramatically from 1900s. Therefore, some early bacterial agents such as Shigella sonnei remains prevalent and new pathogens of fecal origin such as zoonotic C. jejuni and E. coli O157:H7 may contaminate pristine waters through wildlife or domestic animal feces. The common feature of these bacteria is the low inoculum (a few hundred cells) that may trigger disease. The emergence in early 1992 of serotype O139 of V. cholerae with epidemic potential in Southeast Asia suggests that other serotypes than V. cholerae O1 could also getting on epidemic. Some new pathogens include environmental bacteria that are capable of surviving and proliferating in water distribution systems. Other than specific hosts at risk, the general population is refractory to infection with ingested P. aeruginosa. The significance of Aeromonas spp. in drinking water to the occurrence of acute gastroenteritis remains a debatable point and has to be evaluated in further epidemiological studies. Legionella and Mycobacterium avium complex (MAC) are environmental pathogens that have found an ecologic niche in drinking and hot water supplies. Numerous studies have reported Legionnaires' disease caused by L. pneumophila occurring in residential and hospital water supplies. M. avium complex frequently causes disseminated infections in AIDS patients and drinking water has been suggested as a source of infection; in some cases the relationship has been proven. More and more numerous reports show that Helicobacter pylori DNA can be amplified from feces samples of infected patients, which strongly suggests fecal-to-oral transmission. Therefore, it is possible that H. pylori infection is waterbome, but these assumptions need to be substantiated. Giardiasis has become the most common cause of human waterborne disease in the U.S. over the last 30 years. However, as a result of the massive outbreak of waterborne cryptosporidiosis in Milwaukee, Wisconsin, affecting an estimated 403,000 persons, there is increasing interest in the epidemiology and prevention of new infection disease caused by Cryptosporidium spp. as well as monitoring water quality. The transmission of Cryptosporidium and Giardia through treated water supplies that meet water quality standards demonstrates that water treatment technologies have become inadequate, and that a negative coliform no longer guarantees that water is free from all pathogens, especially from protozoan agents. Substantial concern persists that low levels of pathogen occurrence may be responsible for the endemic transmission of enteric disease. In addition to Giardia and Cryptosporidium, some species of genera Cyclospora, Isospora, and of family Microsporidia are emerging as opportunistic pathogens and may have waterborne routes of transmission. More than 15 different groups of viruses, encompassing more than 140 distinct types can be found in the human gut. Some cause illness unrelated with the gut epithelium, such as Hepatitis A virus (HAV) and

Hepatitis E virus (HEV). Numerous large outbreaks have been documented in the U.S. between 1950 and 1970, and the incidence rate has strongly declined in developing countries since the 1970s. Hepatitis E is mostly confined to tropical and subtropical areas, but recent reports indicate that it can occur at a low level in Europe. A relatively small group of viruses have been incriminated as causes of acute gastroenteritis in humans and fewer have proven to be true etiologic agents, including rotavirus, calicivirus, astrovirus, and some enteric adenovirus. These enteric viruses have infrequently been identified as the etiologic agents of waterborne disease outbreaks, because of inadequate diagnostic technology, but many outbreaks of unknown etiology currently reported are likely due to viral agents. Actually, Norwalk virus and Norwalk-like viruses are recognized as the major causes of waterborne illnesses world-wide. The global burden of infectious waterborne disease is considerable. Reported numbers highly underestimate the real incidence of waterborne diseases. The most striking concern is that enteric viruses such as caliciviruses and some protozoan agents, such as Cryptosporidium, are the best candidates to reach the highest levels of endemic transmission, because they are ubiquitous in water intended for drinking, being highly resistant to relevant environmental factors, including chemical disinfecting procedures. Other concluding concerns are the enhanced risks for the classic group of debilitated subjects (very young, old, pregnant, and immunocompromised individuals) and the basic requirement of to take specific measures aimed at reducing the risk of waterborne infection diseases in this growing, weaker population.

PMID: 12546197 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances

Rev Environ Contam Toxicol. 2009;201:71-115. doi: 10.1007/978-1-4419-0032-6_3.

6. **Risk assessment of Pseudomonas aeruginosa in water.**

Mena KD[1], Gerba CP.

Author information

Abstract

P. aeruginosa is part of a large group of free-living bacteria that are ubiquitous in the environment. This organism is often found in natural waters such as lakes and rivers in concentrations of 10/100 mL to >1,000/100 mL. However, it is not often found in drinking water. Usually it is found in 2% of samples, or less, and at concentrations up to 2,300 mL(-1) (Allen and Geldreich 1975) or more often at 3-4 CFU/mL. Its occurrence in drinking water is probably related more to its ability to colonize biofilms in plumbing fixtures (i.e., faucets, showerheads, etc.) than its presence in the distribution system or treated drinking water. P. aeruginosa can survive in deionized or distilled water (van der Jooij et al. 1982; Warburton et al. 1994). Hence, it may be found in low nutrient or oligotrophic environments, as well as in high nutrient environments such as in sewage and in the human body. P. aeruginosa can cause a wide range of infections, and is a leading cause of illness in

immunocompromised individuals. In particular, it can be a serious pathogen in hospitals (Dembry et al. 1998). It can cause endocarditis, osteomyelitis, pneumonia, urinary tract infections, gastrointestinal infections, and meningitis, and is a leading cause of septicemia. P. aeruginosa is also a major cause of folliculitis and ear infections acquired by exposure to recreational waters containing the bacterium. In addition, it has been recognized as a serious cause of keratitis, especially in patients wearing contact lenses. P. aeruginosa is also a major pathogen in burn and cystic fibrosis (CF) patients and causes a high mortality rate in both populations (MOlina et al. 1991; Pollack 1995). P. aeruginosa is frequently found in whirlpools and hot tubs, sometimes in 94-100% of those tested at concenrations of <1 to 2,400 CFU/mL. The high concentrations found probably result from the relatively high temperatures of whirlpools, which favor the growth of P. aeruginosa, and the aeration which also enhances its growth. The organism is usually found in whirlpools when the chlorine concentrations are low, but it has been isolated even in the presence of 3.00 ppm residual free chlorine (Price and Ahearn 1988). Many outbreaks of folliculitis and ear infections have been reportedly associated with the use of whirlpools and hot tubs that contain P. aeruginosa (Ratnam et al. 1986). Outbreaks have also been reported from exposure to P. aeruginosa in swimming pools and water slides. Although P. aeruginosa has a reputation for being resistant to disinfection, most studies show that it does not exhibit any marked resistance to the disinfectants used to treat drinking water such as chlorine, chloramines, ozone, or iodine. One author, however, did find it to be slightly more resistant to UV disinfection than most other bacteria (Wolfe 1990). Although much has been written about biofilms in the drinking water industry, very little has been reported regarding the role of P. aeruginosa in biofilms. Tap water appears to be a significant route of transmission in hospitals, from colonization of plumbing fixtures. It is still not clear if the colonization results from the water in the distribution system, or personnel use within the hospital. Infections and colonization can be significantly reduced by placement of filters on the water taps. The oral dose of P. aeruginosa required to establish colonization in a healthy subject is high (George et al. 1989a). During dose-response studies, even when subjects (mice or humans) were colonized via ingestion, there was no evidence of disease. P. aeruginosa administered by the aerosol route at levels of 10(7) cells did cause disease symptoms in mice, and was lethal in aerosolized doses of 10(9) cells. Aerosol dose-response studies have not been undertaken with human subjects. Human health risks associated with exposure to P. aeruginosa via drinking water ingestion were estimated using a four-step risk assessment approach. The risk of colonization from ingesting P. aeruginosa in drinking water is low. The risk is slightly higher if the subject is taking an antibiotic resisted by P. aeruginosa. The fact that individuals on ampicillin are more susceptible to Pseudomonas gastrointestinal infection probably results from suppression of normal intestinal flora, which would allow Pseudomonas to colonize. The process of estimating risk was significantly constrained because of the absence of specific (quantitative) occurrence data for Pseudomonas. Sensitivity analysis shows that the greatest source of variability/uncertainty in the risk assessment is from the density distribution in the exposure rather than the dose-response or water consumption distributions. In summary, two routes appear to carry the greatest health risks from contacting water contaminated with P. aeruginosa (1) skin exposure in hot tubs and (2) lung exposure from inhaling aerosols.

PMID: 19484589 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Indian J Environ Health. 2001 Apr;43(2):1-82.

7.
Upflow anaerobic sludge blanket reactor--a review.

Bal AS[1], Dhagat NN.

Author information

Abstract

Biological treatment of wastewater basically reduces the pollutant concentration through microbial coagulation and removal of non-settleable organic colloidal solids. Organic matter is biologically stabilized so that no further oxygen demand is exerted by it. The biological treatment requires contact of the biomass with the substrate. Various advances and improvements in anaerobic reactors to achieve variations in contact time and method of contact have resulted in development of in suspended growth systems, attached growth or fixed film systems or combinations thereof. Although anaerobic systems for waste treatment have been used since late 19th century, they were considered to have limited treatment efficiencies and were too slow to serve the needs of a quickly expanding wastewater volume, especially in industrialized and densely populated areas. At present aerobic treatment is the most commonly used process to reduce the organic pollution level of both domestic and industrial wastewaters. Aerobic techniques, such as activated sludge process, trickling filters, oxidation ponds and aerated lagoons, with more or less intense mixing devices, have been successfully installed for domestic wastewater as well as industrial wastewater treatment. Anaerobic digestion systems have undergone modifications in the last two decades, mainly as a result of the energy crisis. Major developments have been made with regard to anaerobic metabolism, physiological interactions among different microbial species, effects of toxic compounds and biomass accumulation. Recent developments however, have demonstrated that anaerobic processes might be an economically attractive alternative for the treatment of different types of industrial wastewaters and in (semi-) tropical areas also for domestic wastewaters. The anaerobic degradation of complex, particulate organic matter has been described as a multistep process of series and parallel reactions. It involves the decomposition of organic and inorganic matter in the absence of molecular oxygen. Complex polymeric materials such as polysaccharides, proteins, and lipids (fat and grease) are first hydrolyzed to soluble products by extracellular enzymes, secreted by microorganisms, so as to facilitate their transport or diffusion across the cell membrane. These relatively simple, soluble compounds are fermented or anaerobically oxidized, further to short-chain fatty acids, alcohols, carbon dioxide, hydrogen, and ammonia. The short-chain fatty acids (other than acetate) are converted to acetate, hydrogen gas, and carbon dioxide. Methanogenesis finally occurs from the reduction of carbon dioxide and acetate by hydrogen. The initial stage of anaerobic degradation, i.e. acid fermentation is essentially a constant BOD stage because the organic molecules are only rearranged. The first stage does not stabilize the organics in the waste. However this step is essential for the initiation of second stage methane fermentation as it converts the organic material to a form, usable by the methane

producing bacteria. The second reaction is initiated when anaerobic methane forming bacteria act upon the short chain organic acids produced in the 1st stage. Here these acids undergo methane fermentation with carbon dioxide acting as hydrogen acceptor and getting reduced to methane. The methane formed, being insoluble in water, escapes from the system and can be tapped and used as an energy source. The production and subsequent escape of methane causes the stabilization of the organic material. The methane-producing bacteria consist of several different groups. Each group has the ability to ferment only specific compounds. Therefore, the bacterial consortia in a methane producing system should include a number of different groups. When the rate of bacterial growth is considered, then the retention time of the solids becomes important parameter. The acid fermentation stage is faster as compared to the methane fermentation stage. This means that a sudden increase in the easily degradable organics will result in increased acid production with subsequent accumulation of acids. This inhibits the methanogenesis step. Acclimatization of the microorganisms to a substrate has been reported to take more than five weeks. Sufficiently acclimated bacteria have shown greater stability towards stress-inducing events such as hydraulic overloads, fluctuations in temperature, fluctuations in volatile acid and ammonia concentrations etc. Several environmental factors can affect anaerobic digestion, by altering the parameters such as specific growth rate, decay rate, gas production, substrate utilization, start-up and response to changes in input. It has long been recognized that an anaerobic process is in many ways ideal for wastewater treatment and has following merits: A high degree of waste stabilization A low production of excess A low nutrient requirements No oxygen requirement Production of methane gas Anaerobic microorganisms, especially methanogens have a slow growth rate. At lower HRTs, the possibility of washout of biomass is more prominent. This makes it difficult to maintain the effective number of useful microorganisms in the system. To maintain the population of anaerobes, large reactor volumes or higher HRTs are required. This may ultimately provide longer SRTs upto 20 days for high rate systems. Thus, provision of larger reactor volumes or higher HRTs ultimately lead to higher capital cost. Among notable disadvantages, it has low synthesis/reaction rate hence long start up periods and difficulty in recovery from upset conditions. Special attention is, therefore, warranted towards, controlling the factors that affect process adversely; important among them being environmental factors such as temperature, pH and concentration of toxic substances. The conventional anaerobic treatment process consists of a reactor containing waste and biological solids (bacteria) responsible for the digestion process. Concentrated waste (usually sewage sludge) can be added continuously or periodically (semi-batch operation), where it is mixed with the contents of the reactor. Theoretically, the conventional digester is operated as a once-through, completely mixed, reactor. In this particular mode of operation the hydraulic retention time (HRT) is equal to the solids retention time (SRT). Basically, the required process efficiency is related to the sludge retention time (SRT), and hence longer SRT provided, results in satisfactory population (by reproduction) for further waste stabilization. By reducing the hydraulic retention time (HRT) in the conventional mode reactor, the quantity of biological solids within the reactor is also decreased as the solids escape with the effluent. The limiting HRT is reached when the bacteria are removed from the reactor faster than they can grow. Methanogenic bacteria are slow growers and are considered the rate-limiting component in the anaerobic digestion process. The first

anaerobic process developed, which separated the SRT from the HRT was the anaerobic contact process. In 1963, Young and McCarty (1968) began work, which eventually led to the development of the anaerobic upflow filter (AF) process. The anaerobic filter represented a significant advance in anaerobic waste treatment, since the filter can trap and maintain a high concentration of biological solids. By trapping these solids, long SRT's could be obtained at large waste flows, necessary to anaerobically treat low strength wastes at nominal temperatures economically. Another anaerobic process which relies on the development of biomass on the surfaces of a media is an expanded bed upflow reactor. The primary concept of the process consists of passing wastewater up through a bed of inert sand sized particles at sufficient velocities to fluidize and partially expand the sand bed. One of the more interesting new processes is the upflow anaerobic sludge blanket process (UASB), which was developed by Lettinga and his co-workers in Holland in the early 1970's. The key to the process was the discovery that anaerobic sludge inherently has superior flocculation and settling characteristics, provided the physical and chemical conditions for sludge flocculation are favorable. When these conditions are met, a high solids retention time (at high HRT loadings) can be achieved, with separation of the gas from the sludge solids. The UASB reactor is one of the reactor types with high loading capacity. It differs from other processes by the simplicity of its design. UASB process is a combination of physical & biological processes. The main feature of physical process is separation of solids and gases from the liquid and that of biological process is degradation of decomposable organic matter under anaerobic conditions. No separate settler with sludge return pump is required, as in the anaerobic contact process. There is no loss of reactor volume through filter or carrier material, as in the case with the anaerobic filter and fixed film reactor types, and there is no need for high rate effluent recirculation and concomitant pumping energy, as in the case with fluidized bed reactor. Anaerobic sludge inherently possesses good settling properties, provided the sludge is not exposed to heavy mechanical agitation. For this reason mechanical mixing is generally omitted in UASB-reactors. At high organic loading rates, the biogas production guarantees sufficient contact between substrate and biomass. Regarding the dynamic behaviour of the water phase UASB reactor approaches the completely mixed reactor. For achieving the required sufficient contact between sludge and wastewater, the UASB-system relies on the agitation brought about by the natural gas production and on an even feed inlet distribution at the bottom of the reactor. (ABSTRACT TRUNCATED)

PMID: 12397675 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances