3/1/11 Bd Mtg. Item 5
Los Osos
Deadline: 2/22/11 by 12 noon

commentletters - 3/1/2011 BOARD MEETING

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Date: Monday, February 21, 2011 2:16 PM
Subject: 3/1/2011 BOARD MEETING
Attachments: antibiotic resistance.jpg; antibiotic resistance-SB.jpg

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SWRCB EXECUTIVE

To: SWRCB & SLO RWQCB, Comments on Item #5 **3/1/2011 BOARD MEETING**

Re: Clerk to the Board at commentletters@waterboards.ca.gov. "**3/1/2011 BOARD MEETING**

DIVISION OF FINANCIAL ASSISTANCE

Item #5

Consideration of a proposed Resolution authorizing funding from the Clean Water State Revolving Fund (CWSRF) to the County of San Luis Obispo Los Osos Wastewater Project (Project), CWSRF Project No. C-06-5230.

The Project will offset potable water use in the Los Osos Groundwater Basin (Groundwater Basin) with California Title 22 disinfected, tertiary-treated recycled water. Recycled water will be **used for urban** and **agricultural irrigation** at sites that currently rely on potable water.

Comment: 1)The moneys allocated to this project should include testing for antibiotic resistant genes (ARGs) in the finished disinfected Title 22 recycled water. If this can not be done because the water is as yet unavailable, a surrogate test could be conducted on similar systems producing this water around the state for ARGs. Sewer plants that are proposed for preparation of recycled water must be capable of also removing CECs and ARGs from the finished product. This is currently not often the situation, thus: 3) Title 22 recycled water as typically produced represents a potentially cumulative and unnecessary adverse impact on human and environmental health.

This comment is is intended to be detailed so that the critical information information is available to the State and Regional Boards and their respective staff, thus allowing for a thoughtful development of policy and regulatory controls on the subject project. Antibiotic resistance is now a fact of life and thus it will be important for the boards and their staff to have some acquaintance with the subject. This is especially critical because the currently designed sewer plants generate the production of antibiotic resistant organisms which are then discharged in large numbers into the environment.

Fm: Dr Edo McGowan, Medical Geo-hydrology, Medical Hydropathology Working Group

The subject of antibiotic resistance, as discussed herein, is important for several reasons. Both human and veterinary medicine are expending considerable resources nationally in attempting to control the accelerating rates of antibiotic resistance. At the same time, resistance is rapidly destroying the remaining antimicrobial drugs that currently exist. To add insult to injury, the pharmaceutical industry seems disinterested in investing in new antimicrobials. Thus the tools available to medicine are diminishing. Concomitantly, the sewer plants, as currently designed and operated are releasing large volumes of antibiotic resistant microbes into the environment, thereby sabotaging the efforts of both human and veterinary medicine to control antibiotic resistance and consequently sewer plants and their byproducts are endangering public health and herd health.

That sewer plants as currently designed and operated do generate and discharge antibiotic resistant bacteria is beyond dispute. The Wastewater Research Division, Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio, conducted a protracted study on the ability of currently designed sewer plants to generate antibiotic resistant bacteria, which are then discharged. This US/EPA study was conducted in the late 1970s and reported in the early 1980s. The report based on the US/EPA study (1982) cited former studies reaching back another decade into the past and these cited studies said the same thing. Thus, although the information could hardly be considered as new, i.e., it has been around for nearly 4-decades, it seems not to have worked itself into the regulatory processes that control sewer plants. Since the State is **prime** for purposes of the Clean Water Act, it is time for the State and its Regional Boards to recognize this shortcoming, hence the need for the detail in this comment. Here is some extracted text from the report of the study conducted by the US/EPA:
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC241834/pdf/aem00183-0119.pdf

"Several researchers have pointed out that wastewater, treated or untreated, is a primary contributor of bacteria to the aquatic ecosystem (12, 16, 17, 20, 27, 29). Studies have been conducted which demonstrate that significant numbers of multiple drug-resistant coliforms occur in rivers (17), bays (9), bathing beaches (28), and coastal canals (13). Waters contaminated by bacteria capable of transferring drug resistance are of great concern since there is the potential

for transfer of antibiotic resistance to a pathogenic species.

When bacteria which carry transmissible R-factors (R+ bacteria) are ingested by a human host, the R-factors may transfer into commonly occurring bacteria of the gastrointestinal tract (32). These organisms may subsequently transfer this resistance to pathogenic organisms, resulting in reduced efficacy of antimicrobial chemotherapy in the event of an infection. In vivo studies have shown that when individuals carrying R+ bacteria are subjected to antibiotic therapy, py, these organisms flourish and transfer their resistance to other bacteria (25)."

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Project (No. C-06-5230)

The project (No. C-06-5230) discusses both municipal irrigation with recycled water and also the use of that water on agricultural lands. This comment will first discuss the use in agriculture. Following that will be a discussion on the use in municipal irrigation and accompanying human health issues. Additional attention should be accorded to the area of effluent discharge, i.e., the location and length of the outfall, the currents and tides and thus the ability for the outfalled sewage effluent to contaminate coastal areas and beach sands. To illustrate this effect, a separate note discussing the Montecito Sanitary District's outfall is attached at the end of this comment.

AGRICULTURE

It is necessary to discuss how irrigation with Title 22 recycled water may impact both the food produced, hence human health and also impact the underlying agricultural base that produces such food. It is well established that the food borne disease outbreaks in the Salinas Valley, through media attention, had badly crippled the area's income, even for farms not even connected with the problem. Nonetheless, the "problem" became a widespread economic disaster.

It is also well established that current water quality tests used by the State of California fail to reflect the actual presence of pathogens often found in the finished and disinfected Title 22 recycled water. This fact is amply demonstrated by the 2004 study by WERF (00-PUM-2T). The essence of that report's findings may be summed by the following sentence: "The failure of measurements of single indicator organism to correlate with pathogens suggests that public health is not adequately protected by simple monitoring schemes based on detection of a single indicator, particularly at the detection limits routinely employed."

This failure is also reflected by my work with finished disinfected Title 22 recycled water tested at two separate sewer districts, in which water we found multi-antibiotic resistant bacteria, see attachments which are photographs of disc diffusion tests of the recycled water showing the extent of the resistance. If you are unfamiliar with reading these test results, please do not hesitate to contact me for assistance. In the case of the finished Title 22 recycled water produced by the El Estero plant, the bacteria were resistant to 11 of the 12 challenge antibiotics. Water from the Goleta plant demonstrated resistance to 4 of the 12 test antibiotics. Unless there are some uncharacteristic factors related to these two plants that produce recycled water per state criteria that make them different from all other plants within the state, we should also find these results generally in most other plants that use these same criteria.

When this water is used to irrigate crops consumed raw, the bacteria and their genetic fragments can, through the consumption of the produce, be transferred to the human gut biota. These resistant bacteria and their genes are able to thus impact both the internal commensal (gut) biota and immune system.

Sjolund (2005) has found that once in the gut, the genetic material has a very long residence life, years. Additionally, once ingested, the plasmids may be transferred to and through normal flora into pathogenic bacteria found in humans or animals, making later treatment with particular antibiotics ineffective (US/EPA also noted this transfer). Additionally, one must consider that the transfer of genetic information from these organisms to more robust organisms might contribute to increased resistance in higher-grade pathogens by interspecies transfer. Sjolund et al go on to note that since populations of the normal biota are large, this affords the chance for multiple and different resistant variants to develop. This accordingly enhances the risk for spread to populations of pathogens. Consequently, by the use of sewage generated recycled water, as currently produced, there is a revolving door between the human population and the sewer plant, especially when foodstuffs are locally grown and consumed when raised on recycled water that is improperly treated.
What goes on food crops which are consumed raw can have long lasting effects. When humans defecate there is production of a fecal veneer around the anal skin. Thus the fecal veneer forming on the perineum would see colonization of adjoining orifices. There are recent studies on vaginal flora were females who had no contact with antibiotics were found with vaginal flora containing drug resistant bacteria. For the pregnant female, this may place the pregnancy at risk, especially if *Listeria monocytogenes* is found in water and soil. According to the Center of Disease Control (CDC), an estimated 2,500 persons become seriously ill each year with *Listeria monocytogenes* in the United States and among these, 500 will die. According to research, pregnant women account for 27% of these cases. CDC claims that pregnant women are 20 times more likely to become infected than non-pregnant healthy adults.
Vegetables can become contaminated from the soil, especially of the bacteria are brought in with the irrigation water. Such an inner connected series as irrigation with recycled water, contamination of crop, consumption of crop, transfer of resistance to gut, movement to fecal veneer, and establishment of resistant contamination in vaginal flora as described immediately above would provide but a single example for project No. C-06-5230, without adequate controls, to become a public health risk.

It is important to understand that there are two basic types of antibiotics with which medicine (human or veterinary) work: bacteriostatic and bacteriocidal. A good primer on this difference has been produced by the National Foundation for Infectious Disease and may be found at http://www.nfid.org/pdf/id_archive/antibiotictherapy.pdf.

Examples:

Bactericidal Drugs: Streptomycin, Sulfonamides, Aminoglycosides
Bacteriostatic Drugs: Tetracycline, Penicillin, Chloramphenicol

Many antibiotics are bacteriostatic and thus merely arrest the growth of bacteria but do not kill them, that job is left for the immune system. But if the immune system is also disrupted by, for example diabetes, and then hit with a chlorine-resistant bacteria, the job of quelling infections, hence the job of medicine, becomes far more complicated. The immune system is designed to produce a chlorine-like material used by the white blood cells to kill bacteria. But if these bacteria are chlorine resistant, this greatly challenges the immune system. If that immune system is already compromised: the very young, the very old, the diabetic, those on immune supressors, etc., the job of medicine is much increased.

Perhaps the case of methicillin resistant *Staphylococcus aureus* (MRSA) is an apt example. MRSA, out of all the various drug resistant pathogens, by itself, now kills more Americans than AIDS, this according to the CDC. Matt Wook Chang (see abstract below), in studying the response of bacteria to chlorine is finding that chlorine up-shifts the capacity of pathogens to cause disease by causing induction of major *virulence* genes. In working with methicillin resistant *Staphylococcus aureus* (MRSA), Chang finds that virulence genes are up-regulated by exposure to chlorine. This response is not limited to this one pathogen but is widely seen amongst bacteria. Dr Marlyn Roberts is finding MRSA along beaches and this issue of beach sands will be discussed later in this document. It is important to note, however, that beach sands offer an excellent medium for the growth and sustenance of pathogenic bacteria.

Thus although pathogens that might otherwise seldom meet in nature to exchange genetic information, upon entering sewer plants are finding themselves forced into close contact within these sewer plants with high levels of gene exchange and then exposed to chlorine. In this situation, the opportunities for development of both enhanced resistance and virulence are elevated. Because bacteria under stress can also enter a dormant state that is not visible to the standard tests, they are missed in the single indicator tests typically used in testing recycled water. This dormant state is called viable but non-culturable (VBNC). WERF has published on this dormant state and has shown that the standard tests used in wastewater and for wastewater byproducts may substantially under represent actual bacterial numbers **by several magnitudes**. Thus, in these conditions, which are common, the standard test results are giving false negatives and thus failing to serve their role in public health protection. We have noted this VBNC when we test finished Title 22 recycled water with the state approved MPN test. When we tested finished disinfected Title 22 recycled water just as it leaves the plant and again at the point of use we got dramatically different results. If we test just as the water is leaving the plant, we get non-detect or very low numbers with this standard testing procedure. When, however, we test this same water with the same test procedure at the point of use the numbers are often quite high and at times completely off the chart. We feel that this dramatic difference is related to resuscitation of bacteria in the VBNC state. It could also reflect the shedding of biofilms. Testing would help differentiate these two potentials. Personally, I think it is both and once the delivery system has an established biofilm that is shedding, the issue of public health is exacerbated. In using the disc diffusion tests as compared to the single indicator MPN test at both point of release and point of use, we get multi-antibiotic resistant bacteria. Thus the standard single indicator tests are not reflecting reality.

Some sewer plants producing recycled water are also using UV light as a disinfectant. There are flaws with this process that warrant some discussion. As noted in the 1982 report from the US/EPA study that demonstrated generation of antibiotic resistance by sewer plants, it will be noticed that UV not only enhanced antibiotic resistance but failed to kill up to 40% of certain

target bacteria. More recently in discussion with Dr. Amy Pruden who works with ARGs, it was mentioned that in close examination of UV disinfection results, although the bacteria were killed, the critical DNA that conferred resistance was not affected. If one were to review the 1928 work of Dr Fred Griffith, it will be found that live bacteria can extract genetic information from heat-killed bacteria.Thus merely killing bacteria with UV is insufficient for public health purposes.

This observation, the non destruction of DNA by UV, by Dr. Pruden is a significant finding because there is a strong reliance on UV in some systems. Dr. Pruden also notes that ARGs are unaffected by chlorine at levels typically used in water quality control and are so small that they will pass through typical filtering systems used by water treatment plants. Consequently, there is the opportunity to see ARGs and gene fragments, which are not amenable to the standard tests, making it through treatment works into the environment. Dr. Pruden is set up to test water samples for ARGs and it is suggested here that the State and thus its Regional Boards contact Dr Pruden to discuss testing of recycled water for ARGs. She may be reached through her university number at (540) 231-3980.

Antibiotic resistant genes that are common to reclaimed water are now also found in drinking water. The fact that sewer plants are generators of antibiotic resistant pathogens whose genes are generally easily taken up and multiplied by the gut biota is an area needing recognition by both the Stare and regional Boards and their respective staff. The ARGs, as I have previously noted, are so small that they pass through many types of filters normally used in water treatment and are not affected by chlorine levels typically used in water treatment. This fact then needs to be inculcated with standards and conditions for permitted uses. For example, if one were to examine the files at the SLO office for the plant in Monterey producing recycled water for the Salinas area, it might be noted that the filters (at least one) was being pushed at 150% of its rated capacity. This over-charge of the filter may well see ARGs moving through the system in large numbers. But based on current standardized tests, that would never be noted, even though the issue of ARGs and health are not disconnected.

The current standards also use proxy or surrogate tests to ascertain water quality. These proxy tests offer a template approach where the template is overlain on the system and if there is a fit, it is assumed that the water is safe. That template related to water clarity and coliform numbers is flawed. The Pomona virus study and its analysis discuss some of these surrogate tests related to water clarity and coliform numbers. In its discussion of this the State itself notes that there is no scientific basis for the reliance on this proxy test. Nonetheless, the regulatory community continues to allow the use of these tests. Much new scientific information has been brought forward since the Pomona study. Additionally, the stakes are now much higher because we are not only losing the battle with antibiotic resistant organisms, but the standards do not consider ARGs, thus there is a serious need to reappraise the tests which underlay the standards.

When we discuss the use of recycled water for irrigation of crops, it is important to understand that crops can internalize bacteria and thus no amount of washing at the kitchen sink has effect on such internalized bacteria. This internalization of bacteria was demonstrated in the 2002 Rutgers University study (see abstract below).

In the case of resistant bacteria and their genes, the bacteria can also interact with the soil commensal biota thus their containment within the soil in which the crops are grown becomes a reservoir for pathogens. This allows for a standing body of bacteria that can enter the roots, thus transferring to the edible portions. As shown by Chad Kinney (see abstract below) certain pharmaceuticals can accumulate in soils and these pharmaceuticals have been shown to be brought in with the recycled (reclaimed) water. The accumulation allows for two detractors, one is the eventual buildup of antibiotics like erythromycin to levels that may key off the development or maintenance of resistance and also, as CECs, may themselves be taken into the crop.

As currently designed and thus operated, many sewer plants can not effectively remove materials in solution. That this is a well documented fact may be seen by the pharmaceuticals now found in the water resources of this nation. There are ways around this with different available technology. That technology can be discussed in a different venue and I am pleased to do so.

A lot of food is now being irrigated with reclaimed sewer water. The State of California allows reclaimed water to be used on crops consumed raw. If this water were properly treated, that would not be a problem. Unfortunately, under current standards and the way sewer plants are designed and run, it can not be properly treated. Thus, leafy greens coming out of ag production areas may be highly suspect, this includes the certified organic. The abstracts below will give you some idea of this issue. Thus while the water may meet standards, it is by no means necessarily safe.

There are provisions in law which allow the Regional Boards to develop standards in areas not covered by current standards. Thus the discussions within this comment document are intended to provide an impetus toward the setting of corrective standards by the boards themselves where the CDPH has not entered the area and where there is a crying need for such standards.

My group is running tests on finished disinfected Title 22 recycled water and finding multi-antibiotic resistant bacteria in the finished product that goes on crops consumed raw. Additionally, as noted above, crops can internalize bacteria and thus no amount of washing at the kitchen sink has effect. Additionally, the plants can internalize pollutants, some of which will biomagnify, i.e., become concentrated within the plants. For example, if a field has too much organochlorine pesticide, one need only plant carrots to clean the soil. The carrots extract the pesticide and bioaccumulate it within the plant's tissues. This is the process called phytoremediation and it is a highly developed and scientifically validated process used globally. We did some of the initial work on developing this process when I was a grad student in the early 1970s at the Environmental Toxicology Department at UC Davis. We tested this with dieldrin and carrots.

Typical sewer plants do not do well with materials in solution and even RO has considerable difficulty in removing flame retardants and about 5% of these materials are found to move through RO. Additionally, certain antibiotics are also not removed by RO and there are recorded failure rates of 20%—this also assumes that these membranes are kept in pristine condition.

Interestingly, the systems that use reclaimed water for crop irrigation do not even go the the extent of using RO.

Chad Kinney, et al (2005) has demonstrated that soil irrigated with recycled water will accumulate pharmaceuticals. These then may biomagnify within the crop grown in that soil.

As to the biomagnification of endocrine disrupters in crops, this is again amply demonstrated in the literature. We do know that endocrine disrupters found in discharged wastewater can, and have, impacted several animal species, birds, fish, amphibians, and worms. Thus, there is potential but unknown impact on humans, especially as such would relate to fetal and first trimester development. Consequently by irrigating crops with recycled water with entrained endocrine mimics and antibiotic resistant microbes, including their genes, the public is being essentially put into a large unauthorized and potentially unethical human experiment.

The levels of endocrine mimics found in recycled water used to irrigate crops must be considered. Bacteria are not the only thing that may be taken into the plants and moved into the edible portions.

IRRIGATION OF MUNICIPAL GREENSCAPE

When this water is used to irrigate greenscape, many of the above discussed problems arise. The bacteria and their genetic fragments can, through the contact, reach the mouth and then enter the human gut biota, moving therefrom to body orifices. As we have seen above, these resistant bacteria and their genes are able to thus impact both the internal commensal (gut) biota and immune system.

Rusin and Gerba have published on finger to mouth transfer of pathogens, see abstracts below. With sprinkler irrigation of recycled water, the aerial transport to off-site surfaces happens and these contaminated surfaces (fomites) allow the transfer of pathogens to humans. There is a good body of literature on sprinkler generation of aerosols that can carry pathogens for considerable distances. The German government has established a set back of 300 meters between sprinklers and habitation. This is not now the case in California where sprinkler irrigation is just across the street from residential neighborhoods. Basum, see below, noted significant drift distances with sprinkler irrigation. This then becomes critical for irrigation around schools and thus on school playing fields where children with immature immune systems are present and have contact with fomites. I think it is not pushing the point to consider the transfer of resistant organisms to school children and then the liability issues that might arise from and to school districts for contamination.

CITATIONS

Sjolund et al. (2005) Emerging Infectious Diseases (Vol. 11, # 9, Sept 2005 @ p. 1389 et seq)

Sara Firl. **The Importance of Municipal Sewage Treatment in the Spread of Antibiotic Resistance**
106th General Meeting of the American Society for Microbiology
May 21-25, 2006, Orlando, Florida. (Session 041/Q, Paper Q-032)

Our study determined that substantial numbers of antibiotic-resistant bacteria were present in municipal wastewater, and that the existing treatment infrastructure did not adequately prevent release of antibiotic-resistant bacteria into the environment.

Validity of the Indicator Organism Paradigm for Pathogen Reduction in Reclaimed Water and Public Health Protection†

Valerie J. Harwood,[1]* Audrey D. Levine,[2] Troy M. Scott,[3] Vasanta Chivukula,[1] Jerzy Lukasik,[3] Samuel R. Farrah,[4] and Joan B. Rose[5]

The validity of using indicator organisms (total and fecal coliforms, enterococci, *Clostridium perfringens*, and F-specific coliphages) to predict the presence or absence of pathogens (infectious enteric viruses, *Cryptosporidium*, and *Giardia*) was tested at six wastewater reclamation facilities. Multiple samplings conducted at each facility over a 1-year period. Larger sample volumes for indicators (0.2 to 0.4 liters) and pathogens (30 to 100 liters) resulted in more sensitive detection limits than are typical of routine monitoring. Microorganisms were detected in disinfected effluent samples at the following frequencies: total coliforms, 63%; fecal coliforms, 27%; enterococci, 27%; *C. perfringens*, 61%; F-specific coliphages, ~40%; and enteric viruses, 31%. *Cryptosporidium* oocysts and *Giardia* cysts were detected in 70% and 80%, respectively, of reclaimed water samples. Viable *Cryptosporidium*, based on cell culture infectivity assays, was detected in 20% of the reclaimed water samples. No strong correlation was found for any indicator-pathogen combination. When data for all indicators were tested using discriminant analysis, the presence/absence patterns for *Giardia* cysts, *Cryptosporidium* oocysts, infectious *Cryptosporidium*, and infectious enteric viruses were predicted for over 71% of disinfected effluents. The failure of measurements of single indicator organism to correlate with pathogens suggests that public health is not adequately protected by simple monitoring schemes based on detection of a single indicator, particularly at the detection limits routinely employed. Monitoring a suite of indicator organisms in reclaimed effluent is more likely to be predictive of the presence of certain pathogens, and a need for additional pathogen monitoring in reclaimed water in order to protect public health is suggested by this study. (Applied and Environmental Microbiology, June 2005, p. 3163-3170, Vol. 71, No. 6)

Lettuce Plants Internalize Bacteria

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Lettuce that has been fertiziled with manure or irrigated with water that is contaminated with *E. coli* O157:H7 can take the bacteria up through its root system and internalize it inside its leaves, resisting traditional external sanitizing methods. Researchers from Rutgers University report their findings in the January 2002 issue of the journal *Applied and Environmental Microbiology*. "In recent years, *E. coli* O157:H7 has been isolated with increasing frequency from fresh produce, including bean sprouts, cantloupes, apples and leaf lettuce. The mechanisms by which the pathogen is introduced into the lettuce plant are not fully understood," say the researchers.

The researchers tested the hypotheses that the source of the contamination may be poorly treated manure (it is estimated that the pathogen is present in over 8 percent of dairy and beef cattle) or irrigation water that has been contaminated with cattle feces. The bacteria were isolated from plants grown using either medium, but interestingly, the researchers found bacteria in the inner tissues of the plants.

"We have demonstrated that lettuce grown in soil containing contaminated manure or irrigated with contaminated water results in contamination of the edible portion of the lettuce plant," say the researchers. "Moreover, the results suggest that edible portions of a plant can become contaminated without direct exposure to a pathogen but rather through transport of the pathogen into the plant by the root system. The inaccessibility of a large number of organisms, as a consequence of their subsurface location, is perhaps the reason for the lack of effectiveness of surface-sanitizing treatments." **(E.B. Solomon, S. Yaron, K.R. Matthews. 2002. Transmission of *Escherichia coli* O157:H7 from contaminated manure and irrigation water to lettuce plant tissue and its subsequent internalization. Applied and Environmental Microbiology, 68: 397-400.)**

Last Updated on Tuesday, 31 October 2006 05:17

Wastewater Derived Pharmaceuticals In Soil Irrigated With Reclaimed Water

Environmental Toxicology and Chemistry

Article: pp. 317–326 | Abstract | PDF (143K)

PRESENCE AND DISTRIBUTION OF WASTEWATER-DERIVED PHARMACEUTICALS IN SOIL IRRIGATED WITH RECLAIMED WATER

Chad A. Kinney[1, 2], Edward T. Furlong[1], Stephen L. Werner[1], and Jeffery D. Cahill[1]

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Three sites in the Front Range of Colorado, USA, were monitored from May through September 2003 to assess the presence and distribution of pharmaceuticals in soil irrigated with reclaimed water derived from urban wastewater. Soil cores were collected monthly, and 19 pharmaceuticals, all of which were detected during the present study, were measured in 5-cm increments of the 30-cm cores. Samples of reclaimed water were analyzed three times during the study to assess the input of pharmaceuticals. Samples collected before the onset of irrigation in 2003 contained numerous pharmaceuticals, likely resulting from the previous year's irrigation. Several of the selected pharmaceuticals increased in total soil concentration at one or more of the sites. The four most commonly detected pharmaceuticals were erythromycin, carbamazepine, fluoxetine, and diphenhydramine. Typical concentrations of the individual pharmaceuticals observed were low (0.02–15 µg/kg dry soil). The existence of subsurface maximum concentrations and detectable concentrations at the lowest sampled soil depth might indicate interactions of soil components with pharmaceuticals during leaching through the vadose zone. Nevertheless, the present study demonstrates that reclaimed-water irrigation results in soil pharmaceutical concentrations that vary through the irrigation season and that some compounds persist for months after irrigation.

Keywords: Pharmaceuticals, Wastewater, Reclaimed water, Soil, Leaching tendencies

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Viability of a low-pressure nanofilter in treating recycled water for water reuse applications: A pilot-scale study

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Available online 24 May 2007.

Abstract

The purpose of this study was to investigate the potential of a low-pressure nanofiltration (NF) membrane for treating recycled water for indirect potable water reuse applications. In particular, the tradeoffs in choosing low-pressure NF over reverse osmosis (RO) were investigated including whether or not significantly lowering operating pressures/costs would result in diminished permeate water quality. A NF membrane (Dow/Filmtec NF-4040) with high permeate productivity was selected for pilot-scale testing over a period of 1200 h at a water reuse facility employing conventional RO membranes for treating tertiary treated wastewater effluent prior to aquifer recharge. The novel application of an NF membrane in treating wastewater effluent for water reuse applications permitted a comprehensive screening of NF permeate water quality and allowed for the investigation of trace organic contaminant rejection on pilot scale with environmentally relevant feed water concentrations. Results from pilot-scale testing highlighted the selectivity of NF membranes in removing organic solutes present in wastewater effluents at the parts-per-trillion level. While operating pressures were by a factor of 2–3 lower than conventional RO membranes, and bulk and trace organic rejection generally exceeded 90 percent, not surprisingly, the rejection of monovalent ions such as nitrate was poor. The poor-to-moderate rejection of monovalent ions, however, resulted in lowered brine stream total dissolved solids concentration and sodium adsorption ratio as compared with the brine stream of conventional RO membranes, which may be beneficial for brine disposal strategies.

Toxicogenomic response to chlorination includes induction of major virulence genes in Staphylococcus aureus

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Abstract

Despite the widespread use of chlorination for microbial control in aqueous environments, cellular response mechanisms of human pathogens, such as Staphylococcus aureus, against chlorination remain unknown. In this work, genome-wide transcriptional analysis was performed to elucidate cellular response of S. aureusto hypochlorous acid, an active antimicrobial product of chlorination in aqueous solution. Our results suggest that hypochlorous acid repressed transcription of genes involved in cell wall synthesis, membrane transport, protein synthesis, and primary metabolism, while amino acid synthesis genes were induced. Furthermore, hypochlorous acid induced transcription of genes encoding major virulence factors of S. aureus, such as exotoxins, hemolysins, leukocidins, coagulases, and surface adhesion proteins, which all play essential roles in staphylococcal virulence. This work implies that chlorination may stimulate production of virulence factors, which provides new insight into host-pathogen interactions and effects of chlorine application for microbial control.

Environmental science & technology 2007, vol. 41, n°21, pp. 7570-7575

J Appl Microbiol. 2002;93(4):585-92.

Comparative surface-to-hand and fingertip-to-mouth transfer efficiency of gram-positive bacteria, gram-negative bacteria, and phage.

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University of Arizona, Department of Soil and Water Science, Building 38, Tucson, Arizona 85721 USA. rusin@ag.arizona.edu

Abstract

AIMS: To determine the transfer efficiency of micro-organisms from fomites to hands and the subsequent transfer from the fingertip to the lip.
METHODS AND RESULTS: Volunteers hands were sampled after the normal usage of fomites seeded with a pooled culture of a Gram-positive bacterium (Micrococcus luteus), a Gram-negative bacterium (Serratia rubidea) and phage PRD-1 (Period A). Activities included wringing out a dishcloth/sponge, turning on/off a kitchen faucet, cutting up a carrot, making hamburger patties, holding a phone receiver, and removing laundry from the washing machine. Transfer efficiencies were 38.47% to 65.80% and 27.59% to 40.03% for the phone receiver and faucet, respectively. Transfer efficiencies from porous fomites were <0.01%. In most cases, M.luteus was transferred most efficiently, followed by phage PRD-1 and S. rubidea. When the volunteers' fingertips were inoculated with the pooled organisms and held to the lip area (Period B), transfer rates of 40.99%, 33.97%, and 33.90% occurred with M. luteus, S. rubidea, and PRD-1, respectively.
CONCLUSIONS: The highest bacteral transfer rates from fomites to the hands were seen with the hard, non-porous surfaces. Even with low transfer rates, the numbers of bacteria transferred to the hands were still high (up to 10(6) cells). Transfer of bacteria from the fingertip to the lip is similar to that observed from hard surfaces to hands.
SIGNIFICANCE AND IMPACT OF THE STUDY: Infectious doses of pathogens may be transferred to the mouth after handling an everyday contaminated household object.

Significance of Fomites in the Spread of Respiratory and Enteric Viral Disease▽

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Worldwide annually there are 1.7 million deaths from diarrheal diseases and 1.5 million deaths from respiratory infections (56). Viruses cause an estimated 60% of human infections, and most common illnesses are produced by respiratory and enteric viruses (7, 49). Unlike bacterial disease, viral illness cannot be resolved with the use of antibiotics. Prevention and management of viral disease heavily relies upon vaccines and antiviral medications (49). Both vaccines and antiviral medications are only 60% effective (39, 49). Additionally, to date there are no vaccines or antiviral drugs for most common enteric and respiratory viruses with the exception of influenza virus and hepatitis A virus (HAV). Consequently, viral disease spread is most effectively deterred by preclusion of viral infection.

Increases in population growth and mobility have enhanced pathogen transmission and intensified the difficulty of interrupting disease spread (14). Control of viral disease spread requires a clear understanding of how viruses are transmitted in the environment (27). For centuries it was assumed that infectious diseases were spread primarily by the airborne route or through direct patient contact, and the surrounding environment played little or no role in disease transmission (19, 27). Up until 1987 the Centers for Disease Control and the American Hospital Association focused on patient diagnosis due to the belief that nosocomial infections were not related to microbial contamination of surfaces (19). Over the years studies have changed the perspective on viral transmission to include a more complex multifactorial model of disease spread (27). There is now growing evidence that contaminated fomites or surfaces play a key role in the spread of viral infections (3, 7, 38, 71).

Viral transmission is dependent on interaction with the host as well as interaction with the environment (60). Viruses are probably the most common cause of infectious disease acquired indoors (7, 71). The rapid spread of viral disease in crowded indoor establishments, including schools, day care facilities, nursing homes, business offices, and hospitals, consistently facilitates disease morbidity and mortality (71). Yet, fundamental knowledge concerning the role of surfaces and objects in viral disease transmission is lacking, and further investigation is needed (52, 60, 61). The goal of this article was to use existing published literature to assess the significance of fomites in the transmission of viral disease by clarifying the role of fomites in the spread of common pathogenic respiratory and enteric viruses.

Comparison of Coliphage and Bacterial Aerosols at a Wastewater Spray Irrigation Site

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Microbiological aerosols were measured on a spray irrigation site at Fort Huachuca, Ariz. Indigenous bacteria and tracer bacteriophage were sampled from sprays of chlorinated and unchlorinated secondary-treatment wastewaters during day and night periods. Aerosol dispersal and downwind migration were determined. Bacterial and coliphage f2 aerosols were sampled by using Andersen viable type stacked-sieve and high-volume electrostatic precipitator samplers.

Bacterial standard plate counts averaged 2.4 x 105 colony-forming units per ml in unchlorinated effluents. Bacterial aerosols reached 500 bacteria per m3 at 152 m downwind and 10,500 bacteria per m3 at 46 m. Seeded coliphage f2 averaged 4.0 x lo, plaque-forming units per ml in the effluent and were detected 563 m downwind. Downwind microbial aerosol levels were somewhat enhanced by nighttime conditions. The median aerodynamic particle size of the microbial aerosols was approximately 5.0 p.m. Chlorination reduced wastewater bacterial levels 99.97% and reduced aerosol concentrations to near background levels; coliphage f2 was reduced only 95.4% in the chlorinated effluent and was readily measured 137 m downwind. Microbiological source strength and meteorological data were used in conjunction with a dispersion model to generate mathematical predictions of aerosol strength at various sampler locations. The mean calculated survival of aerosolized bacteria (standard plate count) in the range 46 to 76 m downwind was 5.2%, and that of coliphage f2 was 4.3%.

THE FOLLOWING IS PRESENTED TO DEMONSTRATE THAT OUTFALL PLACEMENT MAY HAVE A PROFOUND IMPACT ON BEACH CONTAMINATION.

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Several researchers have pointed out that wastewater, treated or untreated, is a primary contributor of bacteria to the aquatic ecosystem (12, 16, 17, 20, 27, 29). Studies have been conducted which demonstrate that significant numbers of multiple drug-resistant coliforms occur in rivers (17), bays (9), bathing beaches (28), and coastal canals (13). Waters contaminated by bacteria capable of transferring drug resistance are of great concern since there is the potential for transfer of antibiotic resistance to a pathogenic species.

McGowan's abstract.....

Short and shallow marine sewer outfalls, a connection with the spread of antibiotic resistance?

Of the 49 sewer outfalls along the California coast, 17 could be considered as short and shallow which may increase marine and beach sand contamination with antibiotic resistant pathogens. Public beaches adjacent to these short shallow outfalls (SSO) may become reservoirs of antibiotic resistance. Studies of beach sand in lake and marine systems have demonstrated contamination with a variety of pathogens. Some studies specifically considered antibiotic resistant Staphylococcus aureus (MRSA) which now kills more Americans than AIDS, according to the CDC.

Beach-goers who dug in the sand or covered themselves with sand were, in the following week or two, more likely to have diarrheal illnesses from a variety of organisms.

Beach sand, especially if it contains ground kelp, offers a good medium for the regrowth and maintenance of pathogens. Do SSO's augment the contamination of coastal beaches and are the bacteria likely to contain antibiotic resistant genetic material? An answer may be gained by tracking effluent released from SSO's. Pilot data indicate effluent may be returned to the beach and near shore waters.

Sewer plants are a principal source for the generation and release of antibiotic resistant bacteria and their genetic material, per peer reviewed published facts for approximately 40 years. US/EPA also published on the topic in 1982. The California Department of Public Health and the Regional Water Quality Control Boards do not recognize this potentially dangerous situation and consequently have generated no standards for its control.

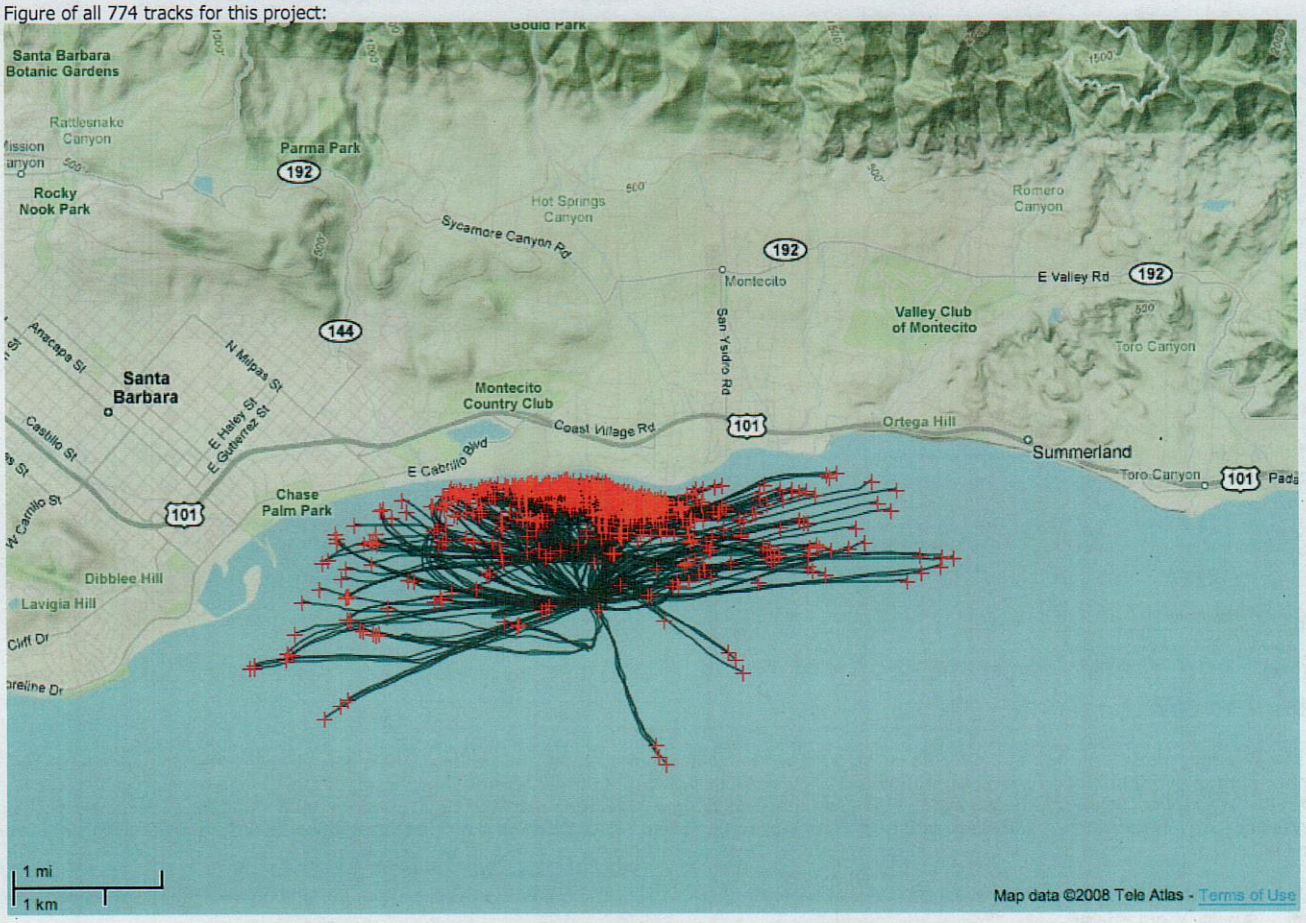
CDC, US/EPA and IATFAR currently plan no research on the subject.

Table of California sewer outfalls which discharge less than ½ mile from shore and depth of less than 40 feet

POTW/WWTP	Miles from shore	Depth in feet
Anchor Bay	0.00	0
Shelter Cove	0.00	0
Fort Bragg	0.12	20
Crescent City	0.13	10
Eureka	0.00	0
Arcata	0.00	0
Half Moon Bay	0.36	37

Daly City	**0.47**	**32**
Ragged Pt Inn	**0.00**	**0**
Summerland	**0.14**	**20**
San Simeon	**0.17**	**20**
Avela Beach	**0.42**	**29**
Montecito	**0.29**	**35**
Carmel Area	**0.11**	**35**
Carpinteria	**0.19**	**25**
San Clemente Ils	**0.00**	**0**
Terminal Ils	**0.17**	**32**
Mendecino	**0.19**	**60**
Avalon	**0.08**	**130**

Figure of all 774 tracks for this project:



Trackers released at the subsurface discharge point of Montecito Sanitary District's sewer outfall showing movement back to beach area and stacking at beach-front. Using these data allows one to argue that released pathogens in the sewage effluent would follow tracker routes. Outfall is 0.29 miles from shore and at a depth of 35 feet. Black lines represent vector of tracker and red + is where tracker stopped its movement.