Public Hearing (12/15/10)
CEC – Recycled Water
Deadline: 1/10/11 by 12 noon

commentletters - Comment Letter – CEC Monitoring for Recycled Water

From: Edo McGowan <edo_mcgowan@hotmail.com>
To: <commentletters@waterboards.ca.gov>, Edo McGowan <edo_mcgowan@hotmail.com>
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Subject: Comment Letter – CEC Monitoring for Recycled Water

Comment Letter – CEC Monitoring for Recycled Water

The CEC Panel, which was not qualified in the area of antibiotic resistance by its own admission, chose, nevertheless, to comment and thus commented inappropriately on the status of antibiotic resistant organisms as found in recycled water meeting Title 22 Standards. This letter is submitted to shed some additional light on the subject. The letter is essentially a copy of work already submitted to the water boards and thus also discusses other wastewater byproducts such as sewage sludge (biosolids). But the inclusion of a discussion on biosolids is useful to this comment because there is a direct relationship between discharged effluent and the load of pollutants and contaminants found in both recycled water and bisolids. What is taken out to make a cleaner effluent or recycled water thus winds up in biosolids and thus the cleaner the end water, the dirtier the biosolids. Since biosolids do wash off the applied areas, this impacts water resources and thus this ties back to water resource quality, hence the raw feed stock of recycled water----------a revolving door.

This author has submitted several comments to the water boards (including the State Board) on the topic of recycled water. Since this topic may eventually wind up in a court of law, it is incumbent upon me to incorporate by reference into this comment all previous submittals to the water boards or State Board to assure that that body of information becomes a clear statement for the public record and thus is not ignored.

POLITICAL IMPLICATION OF ANTIMICROBIAL RESISTANCE BACTERIA IN RECLAIMED WATER FROM TERTIARY WASTEWATER TREATMENT PLANTS.

By: Dr. Edo McGowan

This author possesses a doctorate in water quality control, a BSc degree in medicine, was the former water quality planner for Ventura County and re-wrote the entire Regional Water Quality Control Plan pursuant to Section 208 of the Cean water Act, PL 92-500 for that county.

Based on wastewater industry dogma and standards, released effluent and the land application of sewage sludge are benign and beneficial activities. If however, one reviews the current medical and scientific literature, a different picture emerges, one that raises serious questions about the benevolence of this activity and efficacy of the underlying standards. Thus, the issue takes on aspects of a political and not a scientific argument. In the interim, most regulatory agencies have backed off. This leaves the citizens and patient base standing naked.

Executive Summary

ABSTRACT
This study presents an argument that accelerating risks from both **antimicrobial (antibiotic) resistance** and **pandemic,** especially as now found emerging within the world community, may be related to the disposal of inadequately treated sewage. In the drought-prone areas of the nation, the use of reclaimed or recycled wastewater--- a sewage byproduct, has gained unprecedented acceptance based on the need to both rapidly rid ourselves of waste and at the same time salvage water. While the basic tenet of recycling holds merit, the current processes and standards fail to protect public health. Thus by allowing the use of recycled water produced under current standards and engineering design, the State is placing its citizens at considerable risk.

Recent papers have noted the mixing of genetic material between various organisms provides for newly emerging pathogens. This then challenges our immune systems where we may thus be faced with an unknown foe. Interestingly, much of this mixing goes on every day in sewage treatment plants in almost every city. Down wind movement of aerosols from sewer works now warrants more attention. Additionally, this intermixing affords the opportunity for novel mixes of genetic information between distantly related or unrelated organisms to occur. Hence there is the opportunity for development of new pathogens and thus newly emerging infectious diseases. Although this paper speaks mainly to issues of antibiotic resistance, many of the mechanisms here in apply to other emerging issues related to viruses for which antibiotics are essentially useless. For example SARS or bird flu. SARS was found to be an aerially spread virus. Sprinkler irrigation with recycled wastewater offers a distinct form of aerosol generator as does the flushing of toilets. Several other approved uses of reclaimed or recycled water represent aerosol generators. These uses would include fire fighting, cooling towers, and various industrial uses.

Santa Barbara City College (SBCC) through its various courses offers the opportunity for citizens to examine some aspects of the local community. This author took advantage of that opportunity to examine the potential public health implications accruing to the use of tertiary treated and chlorinated recycled wastewater meeting all applicable state standards and the criteria for Title 22. This water is currently utilized on areas with high public access to irrigate the lawns and playing fields of the campus and thus potentially exposing large numbers of students, faculty, staff and visitors to viable pathogens that can also confer antimicrobial resistance.

This quest was driven, in part, by the compound question: a) did recycled water, as produced under the state criteria (Title 22) a) contain pathogens, b) were those pathogens antibiotic resistant, and c) could that resistance be transferred to the public, and d) if so would such a use have a potential to adversely impact public health impact?

In an attempt to have this water tested, it was noted that there is a low availability of commercial labs that can run tests on water for antibiotic resistance. The local county public health labs can not run these tests. Previous attempts to locate such labs had not met with success. Thus, knowing that the medical microbiology lab (MML) at SBCC had the capacity to run such tests, a course was taken that would allow inclusion of a study design for such testing. That course was offered as Environmental Studies 200 under the guidance of Dr. Adam Green (the interested reader may wish to see SBCC catalogue for a course description).

The California State Water Resources Control Board and its Regional Boards (water boards) control, through statutory directive, the production of recycled wastewater. The production of this water, as produced and under state Department of Health Services (DHS) criteria, is thus presumed to be protective of public health. The water boards indicate that they have no capacity to independently ascertain public health aspects or standards designed for protecting public health. That function, the water boards indicate, rests with DHS. The water boards further indicate that they merely enforce the standards and criteria.

Notwithstanding this disjointed incremental jurisdiction over aspects of presuming to protect public health, statutory directives indicate that public health shall be protected. There is also a memorandum of understanding between the two agencies that spell out abilities and these seem to be at odds with the statement by the Water Boards that they can not ascertain issues of

public health impact. The MOU and other documents that spell out the relationship between the Water Boards and the DHS appear to allow the Water Boards to make determinations of health impacts where such are not specifically covered in standards or criteria by the DHS. This is especially so when one reads the language of Health and Safety Code sections 5410, et seq and finds very much the same language within the Water Code relating to nuisance, contamination and pollution. This will be further discussed presently.

Several scientific papers from the peer-reviewed literature over the last few decades have questioned the safety of sewage byproduct usage where there is high public contact. These papers further question the efficacy of the underlying standards controlling that usage. Other papers, such as those from the Water Environment Research Foundation, (the research arm of the wastewater industry) also note these inconsistencies between standards and the reality of disease.

Independent analyses have raised several compelling questions as to the efficacy of the standards to appreciate newly emerging water born diseases, the pathogens and their genetic material, and thus whether the current standards can in fact protect public health. The more recent readings over the last decade tend to show that the standards do not protect public health. Unfortunately, it appears that the state's regulatory arms that deal with this issue are severely retarded in their capacity to appreciate, hence deal with the situation.

Recycled water can be used for a variety of uses mainly designed to allow for an offsetting in the use of potable water. While this makes strong economic sense, especially within drought-prone areas, that water must not compromise public health. At issue thus, are the inputs to an economic analysis considering the costs to health care and human welfare from adverse impacts of ignored issues such as antibiotic resistance, especially as spread via wastewater byproducts.

The U.S. EPA has not entered the picture with respect to recycled or reclaimed water. EPA has left that subject to the states. EPA does however regulate the land application of sewer sludge (biosolids), but it is experiencing increasing difficulty in justifying that use as health impacts are becoming increasingly well known (see notes 26,27 & 29 below). In the late 1970s and early 1980s, the US/EPA conducted a series of studies on wastewater plants and their generation of antibiotic resistant organisms. That work came out of the Wastewater Research Division, Municipal Environmental Research Laboratory, U.S. Environmental
Protection Agency, Cincinnati, Ohio. Portions of that study's report are included below for added clarity of the issue and to show that the information had been available for nearly three decades to the interested regulators at the state level. The question must thus be raised----why has this critical information not been translated into the current standards?

"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.

Transmission of R-factors in the Enterobacteriaceae usually occurs by conjugation, which involves a specialized structure called the "sex pilus" and requires cell-to-cell contact or cellpilus-cell contact. The ability and the efficiency of different bacterial strains to donate or receive R-factors varies (8). Transmission of R-factors by conjugation is rapid and may spread rapidly among bacteria (31).

When bacteria which carry transmissible Rfactors (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, these organisms flourish and transfer their resistance to other bacteria (25)."

A more recent study by Sjolund noted that once transferred to the human gut biota, the genetic information conferring both resistance and virulence could remain there for years. Thus once this transfer had taken place, one was in essence running about with tiny time bombs in one's belly.

Once ingested, the plasmids may be transferred to normal flora, and subsequently to pathogenic bacteria found in humans or animals, making later treatment with particular antibiotics ineffective. Also one must consider transfer of genetic information from these organisms to more robust organisms indicating that resistance in the normal flora, which may last for years, might contribute to increased resistance in higher-grade pathogens through 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 thus enhances the risk for spread to populations of pathogens. Furthermore, there is crossed resistance. For example, vancomycin resistance may be maintained by using macrolides.
(Sjolund et al. (2005) *Emerging Infectious Diseases* (Vol. 11, # 9, Sept 2005 @ p. 1389 et seq.)

There are a variety of definitions relating to what reclaimed or recycled water actually is. The following list of uses to which recycled water may be put includes: irrigation of public access greenscape such as parks, playing fields, golf courses, and roadway mediums. It may also be used for irrigation of food crops, including those consumed raw. Additionally recycled water may be used in fire fighting, cooling towers, and flushing toilets and urinals within public access restrooms. Further there are myriad industrial uses for this water. In certain areas, this water is injected into aquifers to create a water mound thus is used to control seawater intrusion, or to offset overdraft. The state is now seriously considering direct potable reuse. Again, all these uses are considered, by the state as safe under current standards and that just is not so.

The state statutes (California's Water Code and California's Health and Safety Code) also allow municipal governments to produce recycled water and to force its use upon the community. That this has happened will be noted through an analysis of court records. The forced use at the Montecito Country Club for its golf course is a local example. The Club fought this on liability issue in court and lost. There are several statutory directives that deal with recycled water that were signed into law by prior legislative sessions. Many of these extant laws and their promulgated regulations predate an adequate understanding of the potential public health implications of using inadequately disinfected recycled water. A digest of these code sections is beyond the scope of this paper. Nonetheless, these are the extant directives to those producing such water. Additionally, the directives in state law dictating what knowledge levels are needed to obtain a sewer plant operator's license also fail to appreciate this more current information. Accordingly, those operating sewer plants often fail to appreciate the more current scientific findings as provided by the literature. This disconnect may thus allow sufficient slippage to adversely impact public health yet remain within the dictates of the statutory requirements. This then is seen as a flaw in the administration of the public health requirements, nonetheless a reality of the current political and bureaucratic process.

This report tends to confirm what previous studies had noted, mainly that current standards are not protective of public health (see for example notes 3 & 4 above). This current study, however, noted that the recycled water contained multi-antibiotic resistant bacteria and that these bacteria were potentially serious pathogens. This is a new finding not previously widely reported. While current standards do not discuss issues related to antibiotic resistance, the World Health Organization and Centers for Disease Control and Prevention have been noting an acceleration of mortality and morbidity associated with antibiotic resistance. The CDC now notes that infections with antibiotic resistant pathogens now kill more Americans than AIDS. The WHO has considered antibiotic resistance to be a global crisis for some time.

Prior studies, including studies on the recycled water produced under Title 22 at the sewer plant owned by the City of Santa Barbara, noted that recycled water did contain pathogens and that the standards in use were not protective of public health (see notes 3 & 4 above). In one particular study conducted over a year's time by the Water Environment Research Foundation (WERF), the research arm of the wastewater industry, suggestions were made as to why the sewer plant was failing (see note 4 above). This study was published in 2004. Notwithstanding such studies, the City of Santa Barbara informed members of this study group that the City has made no effort to change its process. Its water meets state standards and that is as far as they will go, notwithstanding the fact and admission that the water contains serious pathogens.

The SBCC Environmental Studies 200 study also ran samples of recycled water produced by Goleta Sanitation District and found it also to contain multi-antibiotic resistant bacteria. Water from Goleta contained bacteria that were resistant to fewer antibiotics but were still considered as multi-drug resistant. Santa Barbara's water contained chlorine resistant bacteria that were resistant to 11 of the 12 test antibiotics whereas Goleta produced water with resistance to chlorine and resistance to 4 of the 12 test antibiotics. It was also suggested by this author that Santa Barbara contact Goleta Sanitation District to ascertain differences in reported pathogen loads and different approaches. It was hoped that Santa Barbara, in cooperation with Goleta could reduce the load of antibiotic resistant pathogens in its produced recycled water. Goleta had significantly better water, the question was why and what did Goleta do that was different? In later contacting Goleta on follow up, this author was informed that Santa Barbara had not contacted Goleta to ascertain differences. In addition, studies were run on Santa Barbara's recycled water using the single indicator MPN tests. Recycled water meeting all state standards was tested just as it left the plant and then down the pipe where it was released. Our multiple tube test uses a 9-Durham tube set with PR lactose as a broth. Findings from these tests demonstrated a non-detect just as the water was released directly at the plant, i.e., 0/0/0/. At the point of use, however, we were getting 3/3/3, which is technically off the chart. Using the 95% confidence limits, the range could exceed 4800.

The regional water boards and the State Board were seeking public comment on a newly designed statewide policy on the use of recycled water. They noe seek comment on the CEC Panel report. The new policy would relax current standards, especially related to provisions of the Clean Water Act (PL 92-500). In the main such relaxed provisions would relate to the control of runoff from areas where recycled water can contact the waters of the state. This, absent an understanding of gene transfer would allow the movement of genetic information from recycled water to waters of the state. There is a strict prohibition in statute for contact between wastewater and state waters. Health and Safety Code 5411---no person (includes city) shall discharge sewage or other waste, or the effluent of treated sewage or other waste, in any manner which will result in contamination, pollution, or nuisance.

It is well demonstrated that runoff from irrigated areas where those areas use recycled water will see that water moving into street gutters and thence storm drains. It is also well documented that street gutters contain biofilms that contain very high levels of bacteria and thus the mixing of genetic information would see the transfer to an already hot situation.

With the above in mind, the reader is now directed to sections of current California law.

H&SC 5410 (f)----nuisance means anything which: 1) is injurious to health, 2) affects at the same time an entire community or neighborhood or any considerable number of persons, and 3) occurs during, or as a result of, the treatment or disposal of wastes.

5410 (d)-----contamination means impairment of the quality of the waters of the state by waste to a degree which creates a hazard to the public health through poisoning or the spread of disease. H&SC 5410 indicates contamination means impairment of the quality of the waters of the state by waste. The waters of the state include any water within the boundary of the state.

This is thus a problem for the State Board's new policy, and is a topic missed by the CEC Panel's final report. It would seem to fly into the face of current statutory law. This author has repeatedly sought clarification on this body of language from the water boards, the State Board, and the DHS, now the CDPH on whether or not antibiotic resistant bacteria and their genes constitute nuisance, contamination, or pollution. This question is one of long standing (years) and at the time of this writing and this comment on the Final Report of the CEC Panel, there has been no forthcoming answer. Failing to get any answer, the author rephrased the question to that of how the state determines what a contaminant, pollutant or nuisance is. Where are the objective criteria, as used by the state's agencies, for making such a determination? How does the state rule in or rule out a material? Again, there has been no answer forthcoming.

Here we can then bring in antibiotic resistance pathogens as well as antibiotic resistant genes (ARGs) and virulence islands (VIs) as components of disease, hence contaminants or pollutants within the above statutes and their definitions thus nuisances.

Thus, if an activity of dealing with pathogens and of disease entities is in fact inherently dangerous, in spite of meeting all requisite standards---there is either something wrong with the standards, or that activity is one that can be classified as ultrahazardous. If ultrahazardous, then presumably strict liability would come into play. The section 13550 (a) (3) may set that up---use of recycled water will not be detrimental to public health.

The establishment of environmental niches containing this genetic material would thus provide avenues for establishment of

lending libraries and potentially movement of resistance into the environment. Thus these areas would be contaminated, hence a nuisance. Above I discussed the issue with street gutters and biofilms where the run-off water reached the waters of the state. Logic dictates that this is a public health issue, but one that currently appears to be ignored by those charged with protecting the public health.

Prior to this study, the State Board had not generally considered the impact of recycled water on the spread of antibiotic resistance, hence the public health implications. During the conduct of this study, documents were submitted to the state and regional water boards discussing the potential public health risks associated with water that contained pathogens and especially resistant pathogens and their genetic material. Pursuant to those comments, an informal panel was created to discuss these comments. That panel met by conference call on Thursday December 6th, 2007, and was composed of about 16 individuals from academia, regulatory government agencies, and industry. Minutes of the meeting are pending as this report is being written. Suffice it to say that the State Board seems to be interested enough in these concerns to pursue the subject. Of additional interest is the result of a meeting between the City of Santa Barbara and faculty of SBCC to discuss the public health implications in using currently produced recycled water. That meeting between faculty and the City culminated in a MOU that would move the analysis to a next phase of inquiry. That next phase would include a more advanced study, presumably by graduate students at UCSB and appropriate faculty. It should also be noted here that the recycled water produced by Santa Barbara additionally used to irrigate community vegetable gardens.

WATER TESTING

The water of interest from both sewer plants was the post chlorination tertiary treated recycled water produced under state criteria as noted within Title 22. This water is used by the University of California at Santa Barbara for irrigating greenscape, including the various sport's playing fields and for flushing the toilets within the Bren School on its first floor. It should be noted here that flushing toilets creates aerosols to which students are exposed as they use the restrooms.

It is also used within the City of Santa Barbara for greenscape, parks, community gardens, playing fields and golf courses, flushing toilets, and irrigation on lands occupied by SBCC. In all cases there is a high degree of public access to these areas.

Goleta: The growth on the Muller-Hinton plate's Kirby Bauer disk diffusion from the pre chlorination water from Goleta demonstrated multi-drug resistant bacteria to all challenges. The post chlorination, however, showed resistance to 4 of the 12 challenge antibiotics. Thus bacteria slipping through the current system were still multi-drug resistant.

Santa Barbara: Water samples from the City of Santa Barbara were all post chlorination. These samples showed two predominant bacterial types, a serratia-like colony and a pseudomonas-like colony. No testing beyond phenotypic identification was conducted. Both of these bacteria were resistant to 11 of the 12 test antibiotics as well as being resistant to chlorine at levels used by the city in its recycled water.

DISCUSSION

Based on these findings, both sewer districts were appraised of the results. In addition, the University Facilities Management as well as Bren School were informed of these preliminary results. Further, a discussion was held between this author and a board member of Goleta West Sanitation District (GWSD) which wheels into Goleta San. Subsequently, the topic was discussed with staff of DHS and comments were issued to the State Board.

While the results were provided to the City of Santa Barbara, staff indicated that there was not much that they could do to change the current situation. Staff of Santa Barbara did agree to meet with SBCC faculty on the subject and see where the issue might be taken. That meeting saw some agreement that additional studies were warranted. Such studies would be sought through the graduate program at UCSB. This author was not present at that meeting.

Staff of DHS indicated that the State Board had initiated inquiries and that a telephone conference was conducted to look at the issue. The board member of GWSD, who is an MD indicated that the issue warranted serious consideration and offered to attempt to bring the topic up through the California Association of Sanitation Agencies (CASA). In a personal communication with WERF, the topic of recycled water prompted interest since WERF is currently looking at antibiotic resistance and pathogens as such would relate to human health risks from the land application of sewage sludge (biosolids). This author is on that scientific panel which includes both WERF and U.S. EPA. From the perspective of the WERF study on biosolids, the addition of recycled water within close proximity of crops receiving biosolid applied to land could see a confounding of WERF study results. A case in point for reference is the Sugar Creek Study (see Appendix), where land application of biosolids saw irrigation water carry antibiotic resistant bacteria to recreational waters. If recycled water were also used in the area, this could confound the results.

The problem seems to be that the subject of antibiotic resistance coming from sewage byproducts, while fairly well known amongst narrow academic groups, is relatively new to those working within the wastewater industry and thus to the regulatory community that over sees this industry. This is an interesting observation since the US/EPA study noted above, has been available for three decades. Consequently a certain (potentially considerable) amount of inertia will need to be overcome, and any resolution to the problem, if one exists, will thus not likely be rapid.

From the perspective of political economics, the debate over the depth and breadth of water pollution, including sanitation, a considerable portion of that debate is beset by uncertainty. The uncertainty accrues to a range of opinion on causation as well as effect. For example, the questions may range from ones of how extensive or important the damage might be to questions asking if the issue indeed has any merit at all.

Thus, within this area of uncertainty, at least five major sources might concern those working in the field. The first is that of the need to measure the extents in degradation. Secondly, this then requires that there be an ability to differentiate human effect from ongoing natural processes. Thirdly, to determine if such differentiation between anthropomorphic versus natural causation is important. And, next, if there is deterioration, then there is likely to be much debate over the variety of ways such deterioration can be viewed and, further if there is then a need to mitigate and finally, how. Ultimately, it comes down to considerations related to the different approaches. What is viewed, what is important, what may be ignored, and the who and how of interpreting the variety of data.

I would argue that water pollution is above all, a political-economic issue, and any discussion and ultimate result will therefore, and unfortunately, rest upon partisan decisions.

Pollution may continue but remain unrecognized or be unimportant to those living in an affected area, i.e., the stakeholder. It only reaches a social issue when deterioration becomes: 1) recognized and 2) some level of action is required. However, until that level of action brings about conflict, pollution has not become a problem. This comment is thus submitted to bring the issue to the forefront of discussion.

When the issue generates conflict, it may be expressed either politically—or it may remain unnoticed as merely the over subscription of alternative scarce resources or the overuse of their absorptive capacities. Unfortunately, so deeply ingrained are the traditional views of humans, which lead to pollution, or its mitigation, that any intervention brings about contradictions within society. Intervention thus implies a mediation or an arising of conditional pressures, especially as regulation shifts from prescriptions to proscription of behavior. An intervention may affect any or all of the following: a) the livelihood of users, b) changes in the allocation of yet other scarce resources, c) changes of the law, or d) rearrangement of pricing structures.

With respect to the environment within a particular basis, some of the leading opinions claim that the level of pollution is not important. That this challenge, if it be such, will, as its advocates claim, induce innovations that can cope with the problems, remains uncertain. These opinions are diametrically opposed to others who may claim that pollution is widespread and serious. In my particular case, I am concerned with pathogens and within that microcosm, those carrying multi-drug resistant mobile genetic elements. The doubts as to whether current designs without considerable innovation can easily cope with current pollution seem well founded.

Resistance has been attributed to drug over-use. Pruden et al and others note a less well-understood mechanism for the amplification of multi-drug resistance, sewage. The local sewer-treatment plant releases pathogens and resistance to the environment and agriculture. Wastewater treatment intermixes organisms otherwise seldom coming together. Selective pressures increase survival mechanisms.

Defense strategies include going dormant, entering the viable but non-culturable (VBNC) state. These VBNC organisms are essentially invisible to the standard laboratory tests used in the wastewater industry. Higgins & Murthy recently reconfirmed this in a paper that raises some serious questions about the efficacy of current standards. Those authors noted that during centrifuged dewatering of sewer sludge, indicators in a VBNC state were resuscitated. The results were several magnitudes greater than standard plate counts had 20 minutes before, indicated. Such findings raise logical questions. If dewatering by centrifuge brought out the essence of VBNC, would other products of sewage that had not been subjected to the centrifuge also in the VBNC state? If so would they revive in the field following application of irrigation with reclaimed wastewater? This seems plausible but needs further study.

Additionally, as stresses increase organisms can acquire genes from or transfer genes to non-related organisms, organisms even within completely different kingdoms. There are other materials dumped into the drain that confer resistance. This includes industrial chemicals, heavy metals, and disinfectants. Triclosan a ubiquitous biocide is suspected of inducing resistance, as are many other industrial materials found in sewage. Changes to the cellular machinery afford the ability to deal with numerous insults, hence cross-resistance. Exposure to chlorine as noted by Chang shifts bacterial genes to see virulence factors up-regulated. As seen by Meckes in the US/EPA study noted above, the use of UV as a disinfectant causes some bacteria to become more resistant. This finding correlates with recent work by Pruden showing that although UV may kill bacteria, the DNA calling out virulence or antibiotic resistance is unaffected. We know from the Work of Fred Griffith (circa 1928) that live non-pathogenic can become deadly pathogens by merely taking up DNA from killed pathogens.

Many antimicrobials including metabolites enter sewage essentially unchanged to induce resistance in the environment . Kummerer and others note levels of antibiotics/pharmaceuticals in sewage able to induce or maintain resistance, hence adding to the risks in crop production through irrigation. But---there are a number of papers demonstrating that absent the input of ntibiotics, sewer plants manufacture antibiotic resistant bacteria.

As noted in the Introduction, based on wastewater (sewage) industry and regulatory opinion, the standards, the released effluent, and its use for crop irrigation or the land application of sewage sludge are benign and beneficial activities . If however, one reviews the current medical and scientific literature, a different picture emerges, one that raises serious questions about the benevolence of this activity and efficacy of the underlying standards . Thus, the issue takes on aspects of a political and not a scientific argument . In the interim, most regulatory agencies have backed off . This leaves the citizens and patient base essentially standing naked.

In 2002 the NAS/NRC called into question the U.S. EPA Part 503 guidelines for land application of sewage sludge (biosolids) and specifically EPA's failure to consider antibiotic resistance. As of writing this comment, EPA has shown little if any progress in investigating resistance. A Freedom of Information Act request to EPA on this subject was submitted in February 2005. The agency has to this day not answered that request. Additionally, the agency has not done health hazards risk analyses for pathogens. Notwithstanding these shortcomings, the agency and the wastewater industry continue to promote the use of sewage byproducts in crop production. Salinas Valley is an example. There is a fairly significant issue attached to this. The state and local regulators often defer to the U.S. EPA on matters dealing with wastewater. In some cases this offers the lower jurisdictions an out. It is not uncommon to hear, "the feds do it this way or the feds have not come up with what ever on this and thus we are at a loss". But in the case of recycled water, the feds clearly are not involved and thus the states and locals are the responsible agencies. As can be seen by this report, the "locals" are ill prepared to act on this critical issue.

A more recent inquiry into this progress and a conversation with Chuck Noss of the EPA noted that the Agency has no scientists working on this issue. In a similar call to CDC, I am told that there also is no focus. Going further to the federal Inter Agency Task Force on Antibiotic Resistance, I am again told that there is no focus on this topic. Thus, in turning to the federal agencies for help in this situation, I think that the state will find little if any help.

Many antimicrobials or their metabolites pass through the body essentially unchanged. Thus feces and urine do contain some impressive levels. As later noted, Kümmerer and others (1999, 2000, 2003, 2004) [2], have followed this and noted levels of antibiotics in sewage that are able to induce or maintain resistance. Added to this are the other materials dumped into the toilet or down the drain that confer resistance. This includes discarded antibiotics and disinfectants such as Triclosan [3] a ubiquitous biocide has been suspected of inducing resistance.

In one of several major studies looking at sewage treatment plants, the scientists followed bacteria through a sewer treatment works using fecal coliforms as the test organism [4]. Coliform bacteria were isolated at various locations in the plant, specifically a) the inlet, b) the primary sedimentation tank, c) the activated sludge digestion tank, d) the final settling tank, e) the outlet and f) the return activated sludge drain. They were then examined the presence of drug resistant plasmids. Using this approach, resistant bacteria and those that were still sensitive to antibiotics were detected [5].

Several drugs were tested and included tetracycline, kanamycin, chloramphenicol and streptomycin, ampicillin, nalidixic acid, rifampicin, and sulfisoxazole. A total of 900 separate tests were conducted, of which more than half contained multi-drug resistant plasmids. While this is interesting, there was a new finding that raised considerable concern. The further along that the wastewater had progressed through the treatment process, the greater the tendency was to encounter strains that had developed multiresistance to antibiotics. Additionally, the study demonstrated that these multi-resistant bacteria also simultaneously carried, and then passed around their multiple transferable drug-resistance plasmids. Thus, the development of drug resistance and the transfer of multi-drug

resistance are enhanced in sewage wastewater treatment plants [5]. These findings have been documented for more than a decade. They were a harbinger, yet little impact from such studies has been noted. Under the current practices, sewage treatment allows the survival of up to 2-million viable coliform per gram of sludge at the point of land application to farmlands [6].

The use of low-level indicator bacteria, along with the apparent lack in understanding of antibiotic resistance within the US/ EPA (see FOIA search results at bottom of this file) should alert anyone that the issue is anything but closed. By its refusal to adequately present necessary analyses in this area, EPA has not only manufactured uncertainty, but also potentially increased the risk of human disease, disease from some serious pathogens that may not respond to current antibiotics. All Class-B sewage sludge technologies that are normally used in the U.S. such as anaerobic digestion and aerobic digestion and heating at these levels as well as composting and land stabilization do not effectively destroy critical pathogens [7]. These practices also do not destroy the genetic material and this and its lack of acknowledgement is a critical shortcoming within EPA. Thus if there is antibiotic resistance within sewer sludge, it may be passed through these processes to background organisms including man [8]. Actually several studies have documented the horizontal transfer of genetic information to background environmental systems and such systems can act as lending libraries for this genetic information. Man and animals are exposed daily to such backgrounds [9]. What are the chances for inadvertent acquisition of resistance from environmental contamination such as through sewage sludge? Gerba and Rusin [10] conducted research about the passage from finger to mouth of pathogens found on typical household objects. Others have documented dust as a mechanical vector for pathogens. Thus what of the dwellings and towns down wind from land application of sewer sludge or from a sewage sludge composting facility? There are now several workmen's comp cases filed by staff of the Chino Women's Prison for complaints accruing to dust from the adjacent and up-wind sewer sludge composting facility in San Bernardino County, California.

Further, there are concerns about wash-off from rains and irrigation return flows. Gerba and others have written extensively about the survival of pathogens and their viable infectivity once they are adsorbed onto sediments [11]. Anyone who lives in an agricultural area knows that tillage and wind cause large movements of soil and dust that are equal to that found for water erosion. The USGS has written extensively on the movement of dust from Africa, across the Atlantic and carrying with it viable pathogens thus causing respiratory disease in the Caribbean [12].

The indicator organisms used for Class B biosolids commonly include Escherichia coli and sometimes Salmonella. These are the organisms that are normally killed by low-level disinfection. They are vegetative bacteria that are highly susceptible to both chemical disinfection and heat disinfection. However, sewage sludge contains a large range of organisms besides E. coli, Salmonella, and Staphylococcus. Also highly susceptible and easily inactivated are the enveloped viruses such as Hepatitis B., HIV, and influenza. While these organisms are fairly easily destroyed, Class-B allows 2 million viable coliform per gram of land applied sewer sludge. This raises the logical question of survival for the more robust organisms.

These bacteria are thus able to colonize environmental niches, and animals, including humans, through ingestion. Once ingested, the plasmids may be transferred to normal flora, and subsequently to pathogenic bacteria found in humans or animals, making later treatment with particular antibiotics ineffective. Also one must consider transfer of genetic information from these organisms to more robust organisms as highlighted by Sjolund et al. (2005) [13] indicating that resistance in the normal flora, which may last up to four-years, might contribute to increased resistance in higher-grade pathogens through interspecies transfer.

These authors 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 thus enhances the risk for spread to populations of pathogens. Furthermore, there is crossed resistance. For example, vancomycin resistance may be maintained by using macrolides [14].

This then brings into question the current paradigm on infection and its dose response to a certain load of a particular pathogen, i.e., ID and LD 50s. Lateral transfer of mobile genetic elements conferring resistance is not considered in this old paradigm. With the prodigious capacity for the gut bacteria to multiply, once the lateral transfer has taken place, very small original numbers---well below the old paradigms can be multiplied into impressive numbers. Since viruses and phages are also involved, their capacity to multiply, which dwarfs that of bacteria, must also be included. Thus there is a need for a new paradigm; unfortunately, the regulatory community seems not to recognize this. When one considers the multiplication within sewer plants and also within their byproducts, disbursement into the environment, the transfer to background organisms, hence to man and his animals, then the remultiplication within commensals, the emerging picture is worrisome.

Further, there are opportunities and interrelationships between microbes that can degrade antibiotics, eg. antibiotic resistant bacteria, and those that can degrade metals as well as pesticides and farm chemicals that are already found in agricultural soils. In many cases, the involved cellular machinery is the same or similar, i.e., a duality (see Schlüter and abstracts of others below).

This duality may have some interesting synergistic survival advantages for the microbes, but bad-for-human-health effects when considering sewer sludge as applied to heavily farmed lands. Thus emerging pathogens arriving through sewer sludge are also introduced to a new suite of resistant soil-dwelling organisms with which to exchange genetic information. The issue of resistance and risk for a pandemic is thus compounded. Since wildlife are not excludable from these sites, this allows the intermixing of micro and macro organism systems. Canadian geese that have landed on sewer sludge land applied areas could be potential vectors. We already know that antimicrobial resistance is now carried by Canadian geese---how did they originally acquire this resistance? Thus, since migratory birds are a potential route for the spread of bird flu, are we thus shooting ourselves in the foot?

The current standards controlling sewer plant operations, the land application of sewer sludge or the composting of sewer sludge for making compost and potting soils consider none of these issues. I therefore contend that this unconsidered avenue for the spread of antibiotic resistance and amplification of risk for a pandemic needs greater awareness within the medical and health care community.

Without the perspective of a broader analysis of this issue, future policy may be no more that the post hoc rationalization for a series of missed opportunities. It would seem reckless to proceed without a broader picture. Unfortunately, the principal regulatory body, U.S. EPA seems to be essentially oblivious to these concepts, yet it has been promoting the land application of sewer sludge. As seen below, based on a FOIA request, EPA seems less than knowledgeable in the area of antimicrobial resistance.

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My group had requested, via Freedom of Information Act, certain data from the U.S. EPA on their progress dealing with biosolids and resistance. In providing us answers to this request, EPA delayed its response for about 6 months and then merely directed us to a section of the NERL's website, which contained no usable information. This site was (www.epa.gov/nerlesd1/chemistry/pharma/fq.htm#disposal), as evidenced by the following search results. Similar results were found for other EPA web addresses.
Results of Searching the "Environmental Sciences" Area of EPA's Web Site
No matches found for transposon; 1402 files searched
No matches found for antibiotic resistance + biosolids; 1402 files searched.
No matches found for antimicrobial resistance + biosolids; 1402 files searched
No matches found for virulent pathogens + biosolids; 1402 files searched.
No matches found for plasmids + biosolids; 1402 files searched.
No matches found for mobile genetic elements; 1402 files searched.
No matches found for high level disinfection + biosolids; 1402 files searched.
Results of Searching EPA's Entire Web Site
We have searched the entire EPA site and found the following results. You may also return to searching for the same terms within Environmental Sciences.
No matches found for high level disinfection + biosolids; 494732 files searched.
No matches found for plasmids + biosolids; 494732 files searched.
No matches found for transposons + biosolids; 494732 files searched.
No matches found for mobile genetic elements + biosolids; 494732 files searched.
No matches found for virulent pathogens + biosolids; 494732 files searched.
No matches found for antibiotic resistance + biosolids; 494732 files searched.
No matches found for antimicrobial resistance + biosolids; 494732 files searched.
Results of Searching the "Exposure Research" Area of EPA's Web Site
We have searched the area of EPA's site related to Exposure Research and found the following results. You may also search for the same terms across EPA's entire site.
No matches found for prions + biosolids; 3352 files searched.
Results of Searching EPA's Entire Web Site
We have searched the entire EPA site and found the following results. You may also return to searching for the same terms within Exposure Research.
No matches found for prions + biosolids; 530969 files searched.
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The 64 508 bp IncP-1 antibiotic multiresistance plasmid pB10 isolated from a waste-water treatment plant provides evidence for recombination between members of different branches of the IncP-1 group
A. Schlüter, et al
The complete 64 508 bp nucleotide sequence of the IncP-1 antibiotic-resistance plasmid pB10, which was isolated from a waste-water treatment plant in Germany and mediates resistance against the antimicrobial agents amoxicillin, streptomycin, sulfonamides and tetracycline and against mercury ions, was determined and analysed. A typical class 1 integron with completely conserved 5' and 3' segments is inserted between the tra and trb regions. The two mobile gene cassettes of this integron encode a -lactamase of the oxacillin-hydrolysing type (Oxa-2) and a gene product of unknown function (OrfE-like), respectively. The pB10-specific gene load present between the replication module (trfA1) and the origin of vegetative replication (oriV) is composed of four class II (Tn3 family) transposable elements: (i) a Tn501-like mercury-resistance (mer) transposon downstream of the trfA1 gene, (ii) a truncated derivative of the widespread streptomycin-resistance transposon Tn5393c, (iii) the insertion sequence element IS1071 and (iv) a Tn1721-like transposon that contains the tetracycline-resistance genes tetA and tetR. A very similar Tn501-like mer transposon is present in the same target site of the IncP-1 plasmid R906, suggesting that pB10, R906 and pJP4 are derivatives of a common ancestor. Interestingly, large parts of the predicted pB10 restriction map, except for the tetracycline-resistance determinant, are identical to that of R906. It thus appears that plasmid pB10 acquired as many as five resistance genes via three transposons and one integron, which it may rapidly spread among bacterial populations given its high promiscuity...".
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Risk Analysis
Volume 24 Page 221 - February 2004
doi:10.1111/j.0272-4332.2004.00425.x Volume 24 Issue 1
A Dynamic Model to Assess Microbial Health Risks Associated with Beneficial Uses of Biosolids Joseph N. S. Eisenberg1* Jeffrey A. Soller2, James Scott1, Don M. Eisenberg2, and John M. Colford, Jr.1
There is increasing interest in the development of a microbial risk assessment methodology for regulatory and operational decision making. This document presents a methodology for assessing risks to human health from pathogen exposure using a population-based model that explicitly accounts for properties unique to an infectious disease process, specifically secondary transmission and immunity. To demonstrate the applicability of this risk-based method, numerical simulations were carried out for a case study example in which the route of exposure was direct

consumption of biosolids-amended soil and the pathogen present in the soil was enterovirus. The output from the case study yielded a decision tree that differentiates between conditions in which the relative risk from biosolids exposure is high and those conditions in which the relative risk from biosolids is low. This decision tree illustrates the interaction among the important factors in quantifying risk. For the case study example, these factors include biosolids treatment processes, the pathogen shedding rate of infectious individuals, secondary transmission, and immunity. Further refinement in methods for determining biosolids exposures under field conditions would certainly increase the utility of these approaches.

McGowan's comments on the Risk Analysis paper------
A brief read of this paper produced the following comments. Principal amongst my thoughts is the paper's limit to pathogens that would not likely multiply outside the host---i.e., viruses. Thus, the model is quite limited from this important perspective. Secondly, there is no consideration of transfer of mobile genetic elements (MGEs) to terrestrial reservoirs, the potential for shifts in genetic information passing through multiple species, and thus the potential for newly emerging diseases. Consequently the issue of transferred antibiotic resistance and similar molecular and cellular machinery is missed. They also do not discuss colonization or later acquiring of resistance, the fecal veneer and thus movement into other organ systems or orifices.
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From: "Strutzel, Jon (DHS-DDWEM)" <JStrutze@dhs.ca.gov>
To: "Edo McGowan" <edo_mcgowan@hotmail.com>
Subject: RE: exams??
Date: Thu, 3 Nov 2005 08:33:08 -0800

Dr McGowan
We do not provide study material for our exams. WE have a list of suggested reading material but it does not cover the subjects you are researching.
-----Original Message-----
From: Edo McGowan [mailto:edo_mcgowan@hotmail.com]
Sent: Thursday, November 03, 2005 6:54 AM
To: abc@abccert.org
Cc: Strutzel, Jon (DHS-DDWEM); scfong@waterboards.ca.gov
Subject: exams??

I'm looking for certification exams guides and study material in wastewater or drinking water that would include discussions in the area of transferred genetic information conferring antibiotic resistance, virulence, or transfer genetic materials between organisms. I am also looking for information on pharmaceuticals in raw water or finished water or wastewater.

Please indicate which of your study guides might contain such information or whether your organization or agency deals with or tests for these subjects.
I look forward to your rapid response via return email.
Dr Edo McGowan, member, Citizens Planning Association of Santa Barbara

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Rick, while EPA does not enter the picture with respect to reclaimed/recycled water, having left that charge to the states, here are some useful ideas from the feds on pollution. Below these excerpts is a discussion on what California state law has to say.

Federal

503.9(t) Pollutant is an organic substance, an inorganic substance, a combination of organic and inorganic substances, or a pathogenic organism that, after discharge and upon exposure, ingestion, inhalation, or assimilation into an organism either directly from the environment or indirectly by ingestion through the food chain, could, on the basis of information available to the Administrator of EPA, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunction in reproduction), or physical deformations in either organisms (humans) or offspring (children) of the organisms.

The CWA is even more specific: 13) The term ``toxic pollutant'' means those pollutants, or combinations of pollutants, including disease-causing agents, which after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring [Humans are one category of Organisms]

The RCRA classifies this pollutants as: (5) The term ``hazardous waste'' means a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may--
(A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

State

Per Calif Water Code 13552.4, a city can force upon residential areas the use of recycled water. Several districts and cities, including Santa Barbara want to ultimately expand with the use of recycled water. By doing so, they can offset potable water and thus allow for expanded development. The other option, of course, is to then sell the offset amount of potable supply to someone else. It would appear that Los Vegas would buy this water credit as an exchange. Thus in the water trade environment, there is much incentive to shift to non-potable sources. If the issues below are not adequately solved from a public health perspective, then whatever expansion occurs will see yet more people put at potential health risks.

Accordingly here is where the work begins for us. How to get the appropriate decision-makers focused on water quality and just not on freeing up more supply and the profits to be gained.

California Water Code Section 13550 (a)(3) states that use of recycled water will not be detrimental to public health. This is echoed in 13521, which controls Title 22. Since Title 22 was put together in 1977, much of the then available science did not and could not consider later scientific findings that have vastly changed the landscape. Thus Title 22 does not consider antibiotic resistance nor antibiotic resistant genes (ARGs) or virulence islands (VI) which are not amenable to chlorine disinfection at levels used by the wastewater industry. These genetic fragments also go through

many of the current filter systems. This was confirmed by the work of Amy Pruden. Title 22 also does not consider VBNC and some of the newly emerging infectious diseases. Nor for that matter, does it consider interactions of heavy metals and pharmaceuticals which may foster the development of resistance.

There are extant technologies that can deal with some of these issues. Accordingly when considering approval of a new treatment plant where designs do not consider the issues discussed above, many of the currently examined projects, considering pathogens, are not achieving BAT and I think that is an important point.

Dried out settling pond or percolation pond surfaces will have a coating of bacterial cells and thus dust containing endotoxins (LPS). LPS as well as high pH materials are serious irritants and allergens as well as inflammatory reaction exciters. These act in concert with pathogens to cause irritation and disruption of protective barriers and thus easier access to disease organisms.

While it would seem that a Regional Water Quality Control Board, in pronouncing on the adequacy of sewer plant designs, must conform to these statutes, these regional boards often merely rubber-stamp projects and give no consideration to these issues.

Health and Safety Code 5410 indicates contamination means impairment of the quality of the waters of the state by waste. The waters of the state include any water within the boundary of the state.

Now the trick would be to also include that water in sewage ponds that is to be used under Title 22, hence water delivered in pipes. That may take some clever thought. Did the law exclude water in pipes? The legislature to exempt something must explicitly state such. I think your legal people need to go to work on this overall problem. Another issue that is being considered by the State Board in its newly revised policy on recycled water is incidental runoff. This while contrary to the CWA, seems to be something encouraged by industry. The issue is the contamination, not with chemicals, but with biological systems that can multiply. These multiplying biological systems can thus establish niches that will constitute lending libraries for terrestrial and aquatic foci of pathogens.

5411---no person (includes city) shall discharge sewage or other waste, or the effluent of treated sewage or other waste, in any manner which will result in contamination, pollution, or nuisance.

5410 (f)----nuisance means anything which: 1) is injurious to health, 2) affects at the same time an entire community or neighborhood or any considerable number of persons, and 3) occurs during, or as a result of, the treatment or disposal of wastes.

This 5410 (f) seems then to loop back to the delivery of Title 22 water to residential areas per 13550 (a) (3) noted above.

5410 (d)-----contamination means impairment of the quality of the waters of the state by waste to a degree which creates a hazard to the public health through poisoning or the spread of disease.

Here we can then bring in antibiotic resistance pathogens as well as ARGs and VIs as components of disease. To the extent that LPS is toxic to tissues, this may fall under the poison as well as disease. The vector issue is another avenue for disease transmission that will likely result.

Those that have access to law libraries may want to look at Toxic Torts as absolute nuisance---see: 16 Western St. LR 5. Being something that falls under absolute, there is no escape for the defendant. This is the beauty of absolute. Same for absolute or strict liability---no excuse is allowed. Thus, if the activity of dealing with pathogens of disease entities is in fact inherently dangerous, in spite of meeting all requisite standards---there is either something wrong with the standards, or that activity is one that can be classified as ultrahazardous. If ultrahazardous, then presumably strict liability would come into play. The section 13550 (a) (3) may set that up---use of recycled water will not be detrimental to public health.

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