Appropriate Degree of Domestic Wastewater Treatment Before Groundwater Recharge and for Shrubbery Irrigation

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Abstract

Considerable controversy exists today on the public health and environmental safety of "reclaimed" domestic wastewaters for reuse for groundwater recharge and ornamental shrubbery irrigation. In some areas such as California only secondary treatment is required by regulatory agencies before domestic wastewater reuse for some purposes. In other areas, treatment equivalent to that provided domestic water supplies and beyond is required/practiced, including ultrafiltration and reverse osmosis. Advocates of minimal treatment before reuse assert that the "risk" to public health and the environment is small compared to the cost of the additional treatment. Further, they rely on soil aquifer treatment to "remove" residual constituents from the domestic wastewaters that are recharged to groundwaters. It is now clear from studies conducted in various areas that pathogenic organisms (enteroviruses and protozoan cysts) and hazardous organics present in secondarily treated domestic wastewater are present in the "reclaimed" wastewater that are threats to public health and the environment. Further, the enteroviruses and some residual organics are being found to be transported in aquifer systems and therefore are a threat to public health for those who use the recovered recharged waters for domestic water supply purposes.

A review of the cost of providing additional treatment to remove potentially hazardous constituents in secondarily treated reclaimed wastewaters shows that the additional treatment costs to use state-of-the-art treatment technology typically are in the range of a few cents per person per day for those who generate the wastewaters and/or use them.

Increasing attention is being given to the quality of stormwater runoff as part of implementing the US EPA's national stormwater quality management program and the protection of domestic water supply watersheds. The endemic waterborne enteric pathogen problem in the US will likely lead to efforts to control residual pathogenic organisms (enteroviruses and parasitic cysts) as well as residual organic and inorganic constituents in the reclaimed domestic wastewaters used for ornamental shrubbery and golf course irrigation. This will lead to increased reclaimed wastewater treatment in an effort to reduce potential sources of constituents that are a threat to public health and the environment associated with runoff from reclaimed wastewater irrigated areas as well as to the users of these irrigated areas for recreational purposes.

A discussion is presented on these issues that leads to the conclusion that very high degrees of domestic wastewater treatment should be practiced to remove known

hazardous constituents in secondarily treated wastewaters that are recharged to aquifers and/or are present in reclaimed wastewater used for golf course and ornamental shrubbery irrigation.

Introduction

Increased demands for domestic water supplies are promoting the development of reclaimed domestic wastewater reuse projects. One of the common uses of reclaimed domestic wastewaters is the irrigation of shrubbery, golf courses, playgrounds, etc. Another increasing use is the recharge of groundwater systems. One of the issues of primary concern in developing domestic wastewater reuse projects is the degree of treatment of the wastewater before its use. There is considerable controversy today about the adequacy of the treatment of reclaimed domestic wastewaters before their use for ornamental shrubbery, golf course, playground, etc. irrigation as well as for enhanced groundwater recharge.

There are domestic wastewater reuse proponents who assert that basically little treatment beyond secondary treatment, including disinfection to control fecal coliforms, is needed to provide public health and environmental "safety" associated with reclaimed domestic wastewater reuse. Other reclaimed domestic wastewater reuse proponents conclude that treatment to only meet secondary domestic wastewater treatment standards, including disinfection to control fecal coliforms, does not provide for the degree of public health and environmental protection that can and should be achieved associated with domestic wastewater reuse projects. These individuals, while supporting domestic wastewater reuse projects for shrubbery and golf course irrigation and groundwater recharge conclude that treatment of domestic wastewaters beyond secondary treatment should be practiced.

This controversy focuses on the potential threat that the residual pathogenic organisms, especially the enteroviruses and cyst-forming protozoans present in secondarily treated domestic wastewaters, represent to cause disease in individuals who have contact with the reclaimed wastewater irrigated areas as well as runoff, including stormwater runoff, from these areas. Also of concern are the residual hazardous and otherwise deleterious chemicals present in secondarily treated domestic wastewaters that could through stormwater runoff from reclaimed wastewater irrigated areas cause stormwater runoff to pollute the receiving waters for the runoff - impairing their use and thereby violating stormwater runoff regulatory requirements.

Cost Issues in Reclaimed Wastewater Reuse Projects

Fundamental to this controversy is the increased cost associated with the additional treatment of domestic wastewaters beyond secondary treatment compared to the additional protection that is provided to public health and the environment associated with the reduced number of pathogenic organisms and reduced concentrations of residual hazardous and otherwise deleterious chemicals present in the treated wastewaters beyond secondary treatment. The Orange County Water District in southern California has been

practicing high degrees of treatment of domestic wastewaters, including reverse osmosis and/or activated carbon beds and advanced disinfection, prior to their use in reclaimed wastewater reuse projects. It is concluded that based on their operating practice the additional cost of this level of treatment is being achieved today at a cost of a few cents per person per day more for those who generate the wastewaters - utilize the reclaimed wastewaters than is typically paid for reclaimed wastewater reuse projects that only practice secondary treatment of the wastewater before reuse.

For some domestic wastewater reuse projects, the additional treatment cost is insignificant compared to the total cost of the project since often the total cost of the project is controlled to a considerable extent by the cost of constructing a pipeline to carry the wastewaters from the treatment works to the areas where the reclaimed wastewater is to be reused.

The secondary treatment reuse advocates frequently assert that the cost of using the additional treatment that can be readily achieved with the technology that is available today is not justified in terms of public health and environmental protection and that the additional cost associated with this treatment could make the domestic wastewater reuse project uneconomical. Their arguments, however, fail to consider the fact that the issue is not the additional cost beyond secondary treatment that should be the determining factor in whether to go ahead with only secondary treatment in a reclaimed wastewater reuse project or use the treatment that could and, in fact, in some locations is being readily achieved with today's technology in domestic wastewater reuse projects.

This additional cost of treating domestic wastewaters beyond secondary treatment in a reuse project should be compared to the cost of other approaches for developing alternative water supplies to meet the ever-increasing demands. It is these demands that are promoting the use of reclaimed domestic wastewaters as an alternative supplemental water supply. In areas where there are adequate high-quality water supplies readily available, there is little interest in developing domestic wastewater reuse projects.

Summary of Recent Reviews on the Need for Additional Treatment in Domestic Wastewater Reuse Projects

There have been a number of reviews on the public health and environmental safety associated with domestic wastewater reuse projects. These include the National Research Council's report (NRC, 1994) [1], "Ground Water Recharge Using Waters of Impaired Quality," which focused on the potential for the residual pathogens and the hazardous chemicals in reclaimed domestic wastewaters to be a threat to the public who utilize groundwaters recovered from an aquifer that has been recharged by domestic wastewaters as part of a domestic wastewater reuse project. It is the position of the NRC committee that there are many unknowns about the safety of using well-treated reclaimed domestic wastewater in groundwater recharge projects. They conclude that such projects likely represent hazards to public health of about the same magnitude as domestic water supplies today.

Public Health Safety of Municipal Water Supplies. Lee and Jones-Lee (1995) [2] in a recently published paper entitled, "Public Health and Environmental Safety of Reclaimed Wastewater Reuse," have reviewed the potential threats that secondarily treated domestic wastewaters represent to public health and the environment when used in reclaimed wastewater reuse projects. Particular attention in their review is given to comments on the NRC (1994) [1] report. They point out that the NRC (1994) [1] report does not address the issue of the "safety" of treated domestic water supplies today in light of the new information that is being developed arising out of the Milwaukee *Cryptosporidium* outbreak that occurred in the spring of 1993.

In April 1993 the city of Milwaukee's *Cryptosporidium* outbreak in which over 400,000 people became ill and over 100 people died occurred even though the water supply met fecal coliform standards. Lee and Jones-Lee (1995) [2] also discuss the fact that the U.S. Public Health Service Centers for Disease Control (CDC) concluded that domestic water supplies that meet fecal coliform standards are resulting in about one million people per year becoming ill in the U.S. and about 1,000 people per year dying due to pathogenic organisms in domestic water supplies that meet fecal coliform standards.

This problem is not the epidemic problem that was experienced in Milwaukee in the spring of 1993 where large numbers of people became ill in a short period of time; it is the endemic waterborne pathogen problem where residual pathogenic organisms in domestic water supplies that meet fecal coliform standards are causing some people to become ill and die. This endemic waterborne pathogen problem is not readily recognized by epidemiological techniques and waterborne disease reporting.

It has been known since the 1940's that the fecal coliform standards are not protective of public health from illness and death associated with the use of domestic water supplies. However, it was not until the Milwaukee epidemic that regulatory agencies took the necessary action to begin to provide for greater public health and environmental protection than that achieved through the fecal coliform standard for both the epidemic and endemic waterborne pathogen problems associated with domestic water supplies.

Lee and Jones-Lee (1993) [3] have developed a comprehensive review of the waterborne pathogen issues associated with domestic water supplies and reclaimed wastewaters. This review should be consulted for further background information on the issues discussed herein with respect to the hazards that the use of the inadequately disinfected reclaimed domestic wastewaters that meet fecal coliform standards represent to those who consume or otherwise have contact with these waters or areas where they have been applied.

There can be little doubt that substantial increased, unnecessary risks are associated with residual pathogenic organisms in reclaimed wastewaters that are only treated to just meet fecal coliform standards. The AWWA June 1995 "Update" [4] states,

"USEPA's Stig Regli, manager of the rule-making effort, said data show crypto occurrence levels in finished water ranging from 1 oocyst/100 L to 1 oocyst/10,000 L,

which translates into a risk range of 1 in 100 to 1 in 10,000 infections, assuming oocyst viability."

Haas *et al.* (1993) [5] reported based on a risk assessment analysis of viruses in drinking water that the U.S. population lifetime risk of death from exposure to waterborne viruses in domestic water supplies is as high as 1 in 20. In the same perspective, typically the US EPA and state regulatory agencies regulate chemical constituents in drinking water, such as non-carcinogens, so that there is zero risk associated with the use of the water. For carcinogens, a risk level of 1 in 1,000,000 is used. It is apparent that the waterborne pathogens in treated water supplies and, for that matter, reclaimed wastewaters are occurring at far greater risks than are allowed for regulated chemical constituents present in treated domestic water supplies.

Public Health Safety of Reclaimed Wastewater Reuse Projects. While no one has developed reliable estimates of the risks of acquiring disease associated with using areas, such as golf courses, that have been irrigated with reclaimed domestic wastewaters that have only received secondary treatment and therefore contain *Cryptosporidium* oocysts as well as enteroviruses, there can be no doubt that this risk is somewhat higher than that associated with the use of a golf course that has been irrigated with reclaimed wastewaters that have been properly disinfected to remove enteroviruses and protozoan cysts. Further, it is very clear that those reclaimed wastewater proponents who assert that playing golf, baseball, or utilizing a park area that has been irrigated with domestic wastewaters that only receive secondary treatment and disinfection to fecal coliform standards is "safe" are ignoring what is well-known today about the ability of these standards to protect public health from enteric diseases.

The authors (Lee and Jones-Lee, 1995) [2] recommend that all areas that are irrigated with reclaimed wastewaters that just meet fecal coliform standards should be posted, warning the public that playing golf, recreating or otherwise using these areas represents a hazard of acquiring enteric diseases that in some individuals can cause death.

Groundwater Recharge with Reclaimed Wastewaters. A more extensive discussion of this topic area, particularly as it relates to groundwater recharge, is provided by Lee and Jones-Lee (1995) [6,7]. An earlier review on groundwater recharge issues was prepared by Lee and Jones-Lee (1993) [8]. These review papers contain extensive references to the literature pertinent to evaluating the public health and environmental threats that residual pathogenic organisms and hazardous and otherwise deleterious chemicals in secondarily treated domestic wastewaters represent to the use of these wastewaters for ornamental shrubbery and golf course irrigation in a reclaimed domestic wastewater reuse project. They also contain information that should be considered in evaluating the hazard that residual pathogens in secondarily treated domestic wastewaters that are recharged to an aquifer represent to those who utilize these waters for domestic purposes.

Further, Lee and Jones-Lee (1995) [6] discuss the significant potential liability that those who develop reclaimed wastewater reuse projects with only minimal treatment of the wastewater before reuse where aquifer soil treatment is used to remove residual

pathogens and hazardous and otherwise deleterious chemicals can be incurring because of the potential for the aquifer to accumulate hazardous or deleterious chemicals in the area where treatment occurs to a sufficient extent so that these areas will become future Superfund sites that will ultimately have to be remediated.

The aquifer treatment process does not necessarily convert all hazardous or deleterious chemicals present in secondarily treated wastewaters to benign substances that represent no threat to future users of the aquifer. It is now becoming well-known, as discussed by Lee and Jones-Lee (1995) [2], through the work being conducted through the Orange County Water District and Stanford University (see Fujita *et al.*, 1995 [9] and Ding *et al.*, 1995 [10]) that there are a number of organic chemical constituents that are present in domestic wastewaters that are recharged to an aquifer that are being transported in the groundwaters to recovery wells with little or no degradation.

It is the authors' position that it is in the best interest of the utility responsible for developing a reclaimed domestic wastewater-based groundwater recharge project that the utility provide high degrees of domestic wastewater treatment before recharge and thereby rely as little as possible on the aquifer to remove constituents present in the treated wastewaters in order to minimize and hopefully avoid the long-term liabilities that the utility will likely incur associated with polluting the aquifer. While this approach may be somewhat more expensive initially than the approaches that are being used in some areas in which only secondarily treated domestic wastewaters are recharged to an aquifer, in the long-term this approach will likely be far cheaper as a result of not becoming a PRP in a Superfund site clean-up.

A problem has recently surfaced with respect to the accumulation of domestic wastewater-derived reclaimed wastewater reuse projects involving groundwater recharge of the wastewaters. This problem is associated with the accumulation of pathogenic organisms, such as protozoan cysts, in the surface slime layer that accumulates in the bottom of the recharge basins. Frequently, this layer needs to be scraped with the slime removed in order to restored the recharge rates that occur with new or reconditioned recharge basins. The issue of concern is the management of the slime layer that is removed from the basin. This layer is likely to contain high concentrations of protozoan cysts and, in some instances, enteroviruses derived from the wastewaters that have been infiltrated through the basin. Unless great care is taken in managing the slime layer, pathogenic organisms in it could be a threat to workers and others who come into contact with it. It appears now that this is an area that has received little or no attention in reclaimed wastewater groundwater recharge projects.

Adequacy of Pro-Minimal Treatment of Wastewater Reports. Frequently, proponents of reclaimed domestic wastewater reuse projects will cite the US EPA (1992) [11] report, "Guidelines for Water Reuse," as an authoritative source of information on this topic. Lee and Jones-Lee (1995) [2], however, have critically reviewed this and other reports such as Crook *et al.* (1994) [12] and USGA (1994) [13] and have found that these pro-reclaimed domestic wastewater with only minimal treatment before use reports do not adequately and reliably discuss the potential public health and environmental threats

associated with the residual pathogenic organisms and hazardous or otherwise deleterious chemicals present in domestic wastewaters that have been only been treated to secondary treatment standards.

Further, they point out that the so-called US EPA (1992) [11] report is not a report of the US EPA, but is a report of a contractor representing a consulting firm that is involved in developing reclaimed wastewater reuse projects. The Agency has not adopted this report as Agency policy. This contractor's report falls far short of reliably discussing the issues that should be considered in developing a domestic wastewater reuse project that is designed to provide true public health and environmental protection to the degree that can readily be achieved with today's wastewater treatment technology. It is also important to understand that the US EPA (1992) [11] report is directed toward situations that are present in developing countries which have significantly different levels of public health protection than those of the U.S. Further, this report was developed several years before the Milwaukee 1993 *Cryptosporidium* incident which, as discussed above, is changing the approach that is used in the U.S. to judge safety of domestic water supplies from waterborne pathogens.

With respect to the USGA (1994) [13] report entitled, "Wastewater Reuse for Golf Course Irrigation," the authors have found that this report fails to adequately discuss the potential threats that the residual pathogenic organisms present in secondarily treated wastewaters that are only disinfected to fecal coliform standards before irrigating golf courses as is now currently allowed in California represent to golfers and runoff waters from the golf courses to the public who come in contact with these waters in acquiring waterborne disease. While Yates (1994) [14] reviews information on the presence of waterborne pathogens in domestic wastewaters used for golf course irrigation, this review fails to discuss the significance of these residual pathogens to golfers who utilize the course.

Monitoring of Reclaimed Wastewater Irrigated Areas. Lee and Jones-Lee (1995) [15] have recently developed a review entitled, "Monitoring of Reclaimed Domestic Wastewater Reuse for Golf Course and Shrubbery Irrigation." In this review they discuss the approach that they recommend for monitoring the use of reclaimed domestic wastewaters for irrigation of shrubbery, golf courses and playgrounds to ensure that enteroviruses and wastewater-derived protozoan cysts do not significantly increase the public health hazard to the users of these areas. While today typical reclaimed wastewater reuse projects involve only monitoring of the treated wastewaters for fecal coliforms, in the future these treated wastewaters should be monitored for enteroviruses and protozoan cysts.

Further, the authors recommend that the areas which receive repeated applications of the treated wastewaters be monitored to determine if there is build-up of pathogenic organisms that represents a threat to the users of the area. The environmental persistence of protozoan cysts is well-known. The repeated application of domestic wastewaters to an area as part of its irrigation could result in the build-up of cysts in the area that would increase the hazard to the users of the area. Further, while it is sometimes assumed that

enteroviruses persist as viable infectious agents for only short periods of time in the environment, the work of Abad *et al.* (1994) [16] has shown that these organisms can persist for considerable periods of time which are generally much longer than those which are typically considered in an area becoming "safe" after these organisms are introduced to it. Lee and Jones-Lee (1995) [15] conclude that the current monitoring of reclaimed domestic wastewater irrigated areas is grossly deficient compared to what should be done to provide for true public health protection from residual pathogenic organisms in the reclaimed wastewaters.

The basic problem that exists today with those that assert domestic wastewaters can be used in reclaimed wastewater projects with minimal (secondary) treatment is that they are ignoring the vast amount of information that has been developed in the past few years on the persistence and impacts of pathogenic organisms commonly present in domestic wastewaters that are not controlled when the wastewater is treated only to meet secondary treatment and fecal coliform disinfection standards. While this issue is not new, it was not until the Milwaukee *Cryptosporidium* outbreak that it gained sufficient regulatory attention so that regulatory agencies at the federal and many local levels are, in fact, finally recognizing that the fecal coliform standard is not protective and that far greater disinfection is needed if true public health protection is to be achieved in reclaimed wastewater reuse projects.

This same situation applies to the discharge of secondarily treated wastewaters to surface water courses. As discussed by Lee and Jones-Lee (1995) [2], contact recreation in surface waters that have received domestic wastewaters that have only been treated to meet fecal coliform standards is now becoming recognized as inadequate treatment to protect public health from acquiring enteric diseases from contact with the surface waters (CDC, 1994 [17] and McAnulty *et al.*, 1994 [18]).

There is also increasing concern being voiced by domestic water supply utilities about the appropriateness of domestic wastewaters being discharged to surface waters that serve as a source of a domestic water supply. Such discharges where the wastewater is only treated to meet fecal coliform standards can significantly increase the *Cryptosporidium* and other pathogenic organism loads that a domestic water utility receives in its raw waters. It is these increased loads of pathogenic organisms that could lead to the endemic domestic water supply waterborne pathogen problem and, in some instances, the epidemic problem of the type that Milwaukee experienced.

It will likely be only a few years before the inadequacies of current regulatory approaches for protection of public health of surface waters that receive domestic wastewaters as well as runoff from areas that receive substantial amounts of some animal fecal matter will be recognized and more appropriately regulated than is being done today. While in the past it has been generally assumed that water containing fecal coliforms principally derived from animals does not represent a significant threat since it was assumed that humans did not acquire disease from contact with animal fecal matter, today it is understood that *Cryptosporidium* is present in the intestinal tract of some warmblooded animals and is excreted in the feces. This will result in regulatory efforts being directed

toward regulating animal feces that contain *Cryptosporidium*from entering surface waters that are used for contact recreation and domestic water supplies.

Conclusion

The authors conclude that there are significant public health and environmental threats associated with reclaimed domestic wastewater reuse projects that utilize only secondarily treated domestic wastewaters in the project for either shrubbery - golf course irrigation or groundwater recharge. Meeting fecal coliform standards in a treated water supply and especially a domestic wastewater does not prevent people from becoming ill and dying from enteroviruses and/or pathogenic protozoan cysts such as *Cryptosporidium*.

It is the authors' position that it is extremely short-sighted and certainly not in the best interests of public health and environmental protection not to provide the additional treatment of the secondarily treated wastewaters before reuse in a reclaimed wastewater reuse project to ensure that the waterborne pathogens such as enteroviruses and protozoan cysts are killed. Further, this treatment should remove potentially hazardous or otherwise deleterious chemicals in the domestic wastewaters that could be a threat to groundwater quality through groundwater recharge, aquifer quality through the accumulation of residual chemicals within the aquifer and surface water quality through the runoff of these chemicals from areas that have been repeatedly irrigated with the reclaimed domestic wastewaters.

Contrary to the assertions that are often made by reclaimed wastewater reuse project proponents, the cost of the additional treatment that is readily accomplishable today is, when properly presented, a small additional cost in additional wastewater treatment and water supply development. Adopting the approach of paying the true cost for reclaimed wastewater reuse is in the best interests of society and will in the long run promote appropriate domestic wastewater reuse as an alternative water supply.

Additional Information

A copy of the authors' papers which provide background information on the topic areas summarized herein is available from the authors upon request.

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