POLICY BRIEF

Addressed to Houston City Council Advocating a Biological Treatment of Hexavalent Chromium in Houston Wastewater

Problem: Hexavalent chromium (Cr(VI)) is a toxic and, in severe cases, carcinogenic form of the element chromium. In 2016, levels of total chromium measured by the Texas Commission of Environmental Quality (TCEQ) were found to be 0.62 ppb on average with levels as high as 6 ppb in some areas.

Risks of Chromium

Chromium is found in multiple oxidation states, but the two found most commonly in the environment are trivalent chromium (Cr(III)) and hexavalent chromium (Cr(VI)). Cr(III) is a relatively benign substrate and is in fact a necessary nutrient for certain body processes. Cr(VI), conversely, has been linked to nasal tissue atrophy, liver and kidney damage, and various cancers. It occurs naturally in the environment at low levels, but elevated levels are generally due to industrial sources such as scrap metal recycling, anti-corrosion coatings, electroplating, and leather tanning.

While there are no cases of death by acute chromium poisoning, prolonged exposure to trace amounts of chromium can lead to health complications such as cancers. The greatest risk of Cr(VI) comes from inhalation of particles suspended in the air or water droplets, and OSHA regulations protect workers in industrial settings from Cr(VI). In the past, ingested Cr(VI) via the oral route was largely disregarded because toxic Cr(VI) becomes reduced to Cr(III) in the stomach. Recently, however, studies on laboratory rats has shown a correlation between benign and malignant stomach tumors and consumption of Cr(VI) over a prolonged period of time.

Current Policy and Regulations

The U.S. Environmental Protection Agency (EPA) only regulates total chromium (Cr(III) and Cr(VI) combined), capping the allowable amount of total chromium at a maximum contaminant level (MCL) of 100 parts per billion (ppb), a standard established in 1991. The justification for measuring total chromium, according to the EPA, is that Cr(III) and Cr(VI) are converted naturally under certain environmental conditions, so they operate under the assumption that

the total chromium level is composed of 100 percent Cr(VI). A report by the National Toxicology Program submitted to the EPA in 2008 has yet to be evaluated to determine whether drinking water standards should be reassessed.

In 2014, California began to regulate Cr(VI) at an MCL of 10 ppb after researchers determined that the minimum level at which cancer rates directly due to Cr(VI) begin to rise is 0.02 ppb, thus becoming the first and only state to monitor specifically Cr(VI). The level was set higher to account for economic and technical feasibility of measuring such trace amounts of the chemical in water treatment facilities. Even at the current regulated levels, a legal appeal in *California Manufacturers and Technology Association and Solano County Taxpayers* has been made to assess the feasibility once more, this time giving greater consideration for smaller water system.

Houston has the third highest average levels of Cr(VI) found in the nation. In Houston, the average level of Cr(VI) was found to be 0.75 ppb. In certain areas, especially in the suburbs surrounding the city, levels are 6 ppb and higher. Although these levels fall below the California regulated level of 10 ppb, and Houston only regulates total chromium per the EPA regulations, Houston legislators have taken notice and called for necessary action. Al Green, Houston's representative for the 9th congressional district, has requested a hearing concerning Cr(VI) levels in Houston, petitioned the EPA about accelerating evaluation of current regulated levels, and created a proposal for subsidizing water filters. Houston city council member Steve Le has also asked Houston Public Works to use alternative methods for testing Cr(VI) and the state Health Department to research the prevalence of cancer in the area. Clearly, the issue of chromium levels and water treatment merit a fairly significant position on the policy agenda.

Treating the Chromium Problem

While monitoring and regulating chromium levels will help maintain levels in Houston, effectively being able to reduce the amount of CrVI already present in the environment is costly. Estimates in a California town set the cost of removing Cr(VI) via methods such as resins, membrane filtration, and iron-based material filters at $27 million per water plant over 20 years. Many of these methods also produces additional chemical wastes that must again be contained and treated, thereby propagating the original problem in a new form.

We would like to propose a synthetic biology solution to treating Cr(VI) contaminated waters. Our project, Hexatri, is an alternative, novel method that uses the model organism *E. coli* and potentially *Shewanella oneidensis* in the future to bioremediate Cr(VI) into Cr(III). Keeping citizens' concerns and EPA regulations regarding microbial biotechnologies in mind, we

designed the plasmid with a kill switch as a containment mechanism so that the bacteria can only thrive in the presence of Cr(VI) in the water. Using the model we created, we can also predict the viability of the microbes in the water treatment systems so as to get an estimate on the costs related to maintaining the chromium reducing mechanism. Implementing our microbe will help to decrease levels of Cr(VI) in Houston waters, thereby reducing human exposure to the toxin and health risks related to Cr(VI).