Department of Toxic Substances Control

Matthew Rodriquez
Secretary for
Environmental Protection

Deborah O. Raphael, Director
5796 Corporate Avenue
Cypress, California 90630

Edmund G. Brown Jr.
Governor

Via Electronic Mail

April 30, 2014

Mr. Michael J. Sullivan, Ph.D., CIH
Consultant to the Fort Mojave Indian Tribe

RESPONSE TO INQUIRY REGARDING HYPERACCUMULATIVE PLANTS AT THE PACIFIC GAS AND ELECTRIC COMPANY (PG&E), TOPOCK COMPRESSOR STATION SITE, NEEDLES, CALIFORNIA (EPA ID NO. CAT080011729)

Dear Dr. Sullivan,

In your November 26, 2013 letter to the Department of Toxic Substances Control (DTSC) and the U.S. Department of the Interior (DOI), you requested specific information from Dr. James Eichelberger of DTSC's Ecological Risk Assessment Section regarding the identification of hyperaccumulative plants at the Topock Site. DTSC is pleased to inform you that Dr. Eichelberger has provided the enclosed memorandum in response to your request on behalf of the Fort Mojave Indian Tribe.

Although potential hyperaccumulative plants may be present at the PG&E Topock site, DTSC notes in your letter that arrowweed in the floodplain will not be harvested, and plant harvesting in the upland portions of the site does not occur. While DTSC understands that the statements in your letter reflects only the Fort Mojave Indian Tribe's position, it is our understanding that other Tribes associated with this project have also agreed with Fort Mojave Indian Tribes to not harvest plants from the project area as long as contamination remains. With this understanding, DTSC and DOI were able to conclude in our March 26, 2014 letter to you that human and ecological exposure to hexavalent chromium via arrowweed uptake represents an insignificant exposure pathway.

DTSC appreciates all the Tribal inputs and considerations provided during the risk assessment workplan addendum scoping discussions. We believe those informative inputs will be well reflected in the draft addendum that PG&E will be submitting. Furthermore, DTSC and DOI welcome any additional inputs that the Tribes may have during the review of the draft addendum currently scheduled for release in early May,

2014. DTSC hopes that the enclosed memorandum provides you with the information that you seek.

Sincerely,

Aaron Yue
Project Manager
Geological Services Branch
Department of Toxic Substances Control

aky: 041401A

Enclosure

cc: Ms. Nora McDowell-Antone
Project Manager Topock Remediation
Ahamakav Cultural Society
Fort Mojave Indian tribe
P.O. Box 5990
Mohave Valley, Arizona 86440

Ms. Linda Otero, Council Member
Director of Ahamakav Cultural Society
Fort Mojave Indian Tribe
P.O. Box 5990
Mohave Valley, Arizona 86440

PG&E Topock Consultative Workgroup Members

PG&E Topock Geo/Hydro Technical Workgroup Members

Tribal Representatives in PG&E Project Contact List

Technical Review Committee

Matt Rodriquez,
Secretary for
Environmental Protection

Department of Toxic Substances Control

Deborah O. Raphael, Director
8800 Cal Center Drive
Sacramento, California 95826-3200

Edmund Gerald Brown Jr.
Governor

MEMORANDUM

TO: Aaron Yue
Senior Hazardous Substances Engineer
Office of Geology
Department of Toxic Substances Control (DTSC)
5796 Corporate Avenue
Cypress, CA 90630

FROM: J. Michael Eichelberger, Ph.D. *J. Michael Eichelberger*
Staff Toxicologist
Human and Ecological Risk Office (HERO)
Ecological Risk Assessment Section (ERAS)

DATE: March 21, 2014

SUBJECT: RESPONSE TO HYPERACCUMULATION QUESTION FROM TRIBAL LETTER OF NOVEMBER 26, 2013 REGARDING FOLLO-UP TO SOIL RISK ASSESSMENT WORK PLAN MEETING, SEPTEMBER 19-20, 2013

PCA: 22120 SITE CODE: 540015-48

Background

On September 19th and 20th of 2013, DTSC facilitated an interagency meeting, which was attended by the Fort Mojave Indian Tribe (Tribe) in Henderson Nevada, to discuss Pacific Gas and Electrics (PG&E) Topock Compressor Station Soil Risk Assessment Work Plan (RAWP). At the request of the DTSC project manager ERAS is providing review and comment to the question concerning hyper accumulation of chromium by plants, as outlined in bullet item 3, on page 2 of the Tribes November 26, 2013 letter. The text of the question is as follows, '*DTSC eco-risk assessor Dr. Eichelberger mentioned that there may be hyperaccumulative plants at the Topock site. The plants mentioned included tumbleweed and Mesquite. The Tribe requests more specific information on the identification of these plants, the portions of the plants that may* *hyper-accumulate metals and which ecological receptors, if any, might be exposed through these plants. The Tribe requests to be able to review this information and discuss it with DTSC and DOI prior to its possible inclusion in the RAWP for ecological receptors.'*

Document Reviewed

ERAS reviewed a single question posed in bullet item number 3 on page 2 of "Follow-up to Soil Risk Assessment Work Plan Meeting, September 19-20, 2013" prepared by Michael J. Sullivan, Ph.D., CIH, Consultant to the Fort Mojave Indian Tribe. Dr. Sullivan's letter is dated November 26, 2013, and ERAS received the letter for review by electronic mail on January 13, 2014. Hereafter, the letter will be referred to as 'Report' in the following ERAS response.

ERAS Response

Potential hyperaccumulator plants

1. Mesquite

Mesquite species (*Prosopis sp.*) have been shown to have higher concentrations of CrVI in roots (5035 mg CrVI /kg root dry weight taken up from 2.0 mM CrVI solution., and 8090 mg/kg root dry weight taken up from 3.4 mM Cr VI solution) and shoots (2,364 mg/kg dry weight shoots taken up by roots and translocated to shoots from 2.0 mM Cr VI solution., and 5,461 mg/kg shoot dry weight taken up by roots and translocated to the shoots from 3.4 mM CrVI solution), than CrVI in solution (hydroponic) (Buendia-Gonzalez et al. 2010).

Aldrich et al, (2003) also found accumulation of Cr in plant tissues in studies where mesquite seedlings were grown in an agar media containing either 75 ppm or 135 ppm CrVI. Table 1 below is a reproduction of Table 1 from Aldrich et al. Values are reported in mg Cr/kg dry weight. Aldrich *et al*, concluded that mesquite is a Cr hyperaccumulator.

Table 1 Cr Uptake data for mesquite grown in Agar media

Tissue Conc (PPM)	Control	75 ppm	125ppm
Leaf	0.03±0.0	322.8±69.1	991.5±114.9
Stem	0.0±0.0	889.9±137.1	1162.±981.2
Root	0.02±0.0	7636.3±2463.4	10983.8±1641.9

The Topock Groundwater Remediation Project Floristic Study (PFS) (2013) describes two species; honey mesquite (*Prosopis glandulosa var. torreyana*), and screwbean mesquite (*Prosopis pubescens*) on the Topock site. Screwbean mesquite has been planted in the flood plain adjacent to the river and Honey Mesquite is found in drainage areas such as Bat Cave Wash and the East Ravine.

According to the Fire Effects Information System (FEIS), honey mesquite seeds are a valuable food source for a wide variety of birds and mammals (http://www.fs.fed.us/database/feis/plants/tree/progla/all.html) and the leaves are foraged sparingly by jackrabbits and woodrats. Buds and flowers are fed upon by quail. The literature does not contain information regarding bioaccumulation of chromium in Mesquite seeds.

2. Paloverde

Parkinsonia aculeate (*Parkinsonia aculeate*) Mexican palo verde grown in hydroponic solutions containing 70 mg/L CrIII and 30 mg/lL Cr VI for 14 days contained 200 mg/kg Cr (dry weight) in the leaves (Zhao et al, 2009). Three species of palo verde are listed in the PFS. Mexican palo verde is a planted species associated with landscaping. Blue palo verde (*Parkinsonia florida*) and hillside palo verde (*Parkinsonia microphylla*) are native species within the Topock Compressor Station soil study area. Mule deer and bighorn sheep browse blue palo verde shoots and leaves and small mammals feed on the seeds during summer and fall (http://www.fs.fed.us/database/feis/plants/tree/parflo/all.html). Hillside palo verde is browsed by mule deer, bighorn sheep, jackrabbits and rodents. The species is also a source of food for birds (http://www.fs.fed.us/database/feis/plants/shrub/parmic/all.html#MANAGEMENT%20CONSIDERATIONS).

3. Russian Thistle

Russian thistle (*Salsola kali)* grown on agar containing 20 mg/L of either Cr VI or Cr III accumulated 600 and 33 mg/kg dry weight respectively (Gardea-Torresdey et al 2005). The PFS lists *Salsola tragus occurring on the site.* The Jepson Flora Project on the Jepson Interchange (http://ucjeps.berkeley.edu/interchange.html) lists seven species of *Salsola* in the state. The PFS lists *Salsola tragus* as occurring on site. *Salsola species are all non-native invasive weeds native to southern Europe, Asia, and possibly Australia.* Small mammals eat the seeds as well as granivorous birds including Gambel's quail (http://www.fs.fed.us/database/feis/plants/forb/salkal/all.html).

Plant Uptake and Translocation

Although a plant may be able accumulate Cr in its tissue, ultimately the presence of Cr in the upper portions of the plant is dependent on the chromium compounds in the soil and the associated valence of the chromium in those compounds. It should be noted that in all of the studies reported on in this memorandum, each study utilized Cr III and Cr VI in solution, either in hydroponic studies or investigations with agar as the media. No soil was used as part of these assessments of uptake of chromium.

Chromium exists in the environment in many chemical compounds and those in which the Cr is in the Cr III or Cr VI valence states are ecologically relevant. Compounds containing Cr in the Cr III valence state are highly insoluble; those in the Cr VI valence are generally very soluble. Therefore in soils, Cr III is partitioned almost exclusively to the soil, whereas Cr VI Partitions to the water in the soil (pore water).

The plant roots do not take up metals in the solid state (ie., those sorbed to the soil particles), they must be in solution to be taken up. It stands to reason therefore, that under field conditions, it is far more likely for plant roots to take up Cr VI, than Cr III. This would occur when the soil is wet, after a rain when there is porewater. A second scenario is one in which plants have their roots in subsurface water, such as groundwater, that is close enough to the surface that certain plants can reach this water source with their roots.

The largest fraction of Cr (whether Cr III or Cr VI) taken up by the plant root, and remains in the root. However, as demonstrated in the papers discussed earlier in this memorandum, a portion of the Cr taken up by the root is translocated up the stem and to the leaves. The literature has demonstrated that in the plant root, Cr VI is biologically reduced to Cr III. (Arteaga *et al*, 2000). Cr III has also been shown in studies not using acid tissue digestion to be transported through the plant vasculature up the stem to the leaves (Zhao *et al* 2009). Cr transported in the stems is transitory with the leaves as a destination, however there is an observed trend in the literature with concentrations in root > stem > leaves. Whichever form of Cr is taken up, the valence expected in the upper portions of the plant is likely to be Cr III. Both stems and leaves may contain chromium. To ERAS' knowledge there is no information regarding chromium transport to the seeds of the species discussed in this memorandum.

Conclusions

ERAS would be happy to discuss this topic with the tribe and their consultant. In regard to the soil risk assessment workplan, hyperaccumulator plants should be discussed as an uncertainty. A standard USEPA uptake factor has been approved in the risk assessment work plan. It is not likely there is significant plant uptake of Cr III by plants from soil. Any plant that may have roots that reach a groundwater source such as mesquite or palo verde could take up Cr VI, reduce it to Cr III in the roots and transport Cr III up the stem to the leaves in concentrations greater than the CR VI in the groundwater. The same could occur for a plant growing in soils containing Cr VI when the soil is wet. Short of a validation study to confirm Cr uptake by plants growing in site soils, it is not possible to confirm if hyperaccumulation has occurred.

References

Aldrich, M.V., J.L. Gardea-Torresdey, J.r. Peralta-Videa, and J.G. Parsons. 2003. Uptake and reduction of Cr(VI) to Cr(III) by Mesquite (*Prosopis spp.*): Chromate-Plant Interaction in Hydroponics and solid Media Studed Using XAS. Environ. Sci. Technol. 37:1859-1864.

S. Arteaga, J. L. Gardea-Torresdey, R. Chianelli, N. Pingitore, W. Mackay, and J. Arenas. Spectroscopic Confirmation of Chromium Uptake by Creosote Bush (*Larrea tridentata*) Using Hydroponics. 2000. Proceedings of the 2000 Conference on Hazardous Waste Research.
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCsQFjAA&url=http%3A%2F%2Fciteseerx.ist.psu.edu%2Fviewdoc%2Fdownload%3Fdoi%3D10.1.1.3

84.9767%26rep%3Drep1%26type%3Dpdf&ei=DVcrU6acJZD7oATvqYKwCQ&usg=AFQjCNHVBPXfEh3_6BFOKteO30_Bs0W9Aw&bvm=bv.63316862,d.cGU.

Buendia-Gonzalez, L. J. Orozo-Villafuerte, F. Cruz-Sosa, C.E. Barrera-Diaz and E.J. Vernon-Carter. 2010. *Prosopis laevigata* a potential chromium (VI) and Cadmium (II) hyperaccumulator desert plant. Bioresource Technology 101:5862-5867.

Gardea-Torresdey, J.L., G.de la Rosa, J.r. Peralta-Videa, M. Montes, G. Cruz-Jimenez and I. Cano-Aguilera. 2005. Differential uptake and transport of trivalent and hexavalent chromium by tumbleweed (*Salsola kali*). Arch. Environ. Contam. Toxicol. 48:225-232.

Topock Groundwater Remediation Project Floristic Study Report. 2013.

Zhao, Y., J.G. Parsons, J.R. Peralta-Videa, M.L. Lopez-Moreno and J.L. Gardea-Torresdey. 2009. Ue of synchrotron-and plasma-based spectroscopic techniques to determine the uptake and biotransformation of chromium(III) and chromium (VI) by *Parkinsonia aculeate.* www.rsc.org/metallomics. 1:330-338.

Reviewed by: Brian Faulkner, Ph.D.
Staff Toxicologist, ERAS

Cc: James M. Polisini Ph.D.
Senior Toxicologist HERO/ERAS