Updates to the Spatial Analysis and Decision Assistance (SADA) Freeware Tool – 16583

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ABSTRACT

SADA is a collaboration between the University of Tennessee and Oak Ridge National Laboratory to present a freeware desktop application integrating environmental risk analytics, spatial modeling, and decision sciences for use at EPA, NRC, DOE, and DoD contaminated sites. The software embeds risk assessment, uncertainty modeling, and downstream decision processes within a spatial context. Updates to Version 6 will provide will include a rich GIS environment and a new 3-D visualization model which permits immersive visualization of contamination, with topology, and the built environment. The risk models presented are developed in conjunction with Superfund to implement all scenarios in their Regional Screening Levels (RSLs) and radionuclide preliminary remediation goals (PRGs). In addition, SADA will be able to ingest high resolution LandScan population data providing insights into the proximity of population to contamination. A brief overview of the progress in provided along with anticipated next steps.

INTRODUCTION

Spatial Analysis and Decision Assistance (SADA 2015) version 5 is free software that incorporates tools from environmental assessment fields into an effective problem solving environment. These tools include integrated modules for visualization, geospatial analysis, statistical analysis, human health risk assessment, ecological risk assessment, cost/benefit analysis, sampling design, and decision analysis. The capabilities of SADA can be used independently or collectively to address site specific concerns when characterizing a contaminated site, assessing risk, determining the location of future samples, and when designing remedial action. A fully functional freeware version is available on the download page of this web site. SADA is developed in The Institute for Environmental Modeling at the University of Tennessee.

Since 1998, SADA is an evolving freeware product targeted to individuals performing environmental assessments in support of decision-making. The primary objective is to create a user friendly software package for environmental characterization and decision-making. This problem solving environment applies and integrates a number of algorithms that can either be used in a stand-alone fashion or in the direct support of performing a site assessment. The software processes and produces information in a clear, transparent manner, directly supporting decision processes, and can serve as a communication tool between technical and non-technical audiences. The end result is that SADA can be used to facilitate decisions about a given site in a quick and cost effective manner. SADA has a strong emphasis on the spatial distribution of contaminant data and is therefore best suited for anyone who needs to look at data within a spatial context, such as: Statisticians, Risk Assessors, GIS Users, Project Managers, Stakeholders and MARSSIM Analysts.

Ultimately, our objective is to provide environmental assessors with a unified software package that links practical characterization tools to decision-making capabilities (particularly human health and ecological risk assessment). The integration of the human health risk capabilities of SADA with modules for ecological risk assessment can help accomplish EPA's mission as outlined in the Ecological Research Strategy to: "develop and demonstrate a multiple pathway, multiple chemical model that integrates human health and ecological cumulative exposure and risk assessments." In addition, using the same problem solving environment for human health and ecological risk assessment assures consistency between the two assessment efforts in terms of the data that is used and the decision rules that are addressed. Our intention is to maintain it as a free product that will not depend on other software products (other than Windows).

METHODS

SADA version 6 will provide updates to the geospatial information system platform, the 3-D viewing capability, the human health risk assessment models and software coding backbone.

Figure 1 shows the SADA version 5 GIS simple visualization. The visualization techniques in SADA are simple to use, easy to understand, and facilitate the data exploration, modeling, and decision analysis components present in SADA. A number of functions are available that will be recognizable to GIS analysts and introduce beginners to GIS tools. SADA can be applied to a wide range of applications where spatially distributed information plays a role. However, SADA was engineered with environmental characterization and remediation in mind. For the sake of simplicity we will talk about visualization with an emphasis on environmental applications.

SADA provides a number of methods for the exploration of spatial data in two or three dimensions. By data we mean point sampled data as well as continuous models. Two-dimensional information is presented as simple xy plots or as GIS rich mappings. Three-dimensional information is presented in two ways: by 2-D slices (layers) or by 3-D volume. Figure 2 presents SADA version 5 3-D visualization. In the layer approach, the user can easily set the depth of each of the layer in order to suit the particular needs of the investigator. The 3-D volume approach does not depend on any layering scheme and shows all depths at once. The volume view can be customized with a variety of features that allow the user to better characterize contamination at depth.

In order to allow data visualization with respect to site characteristics, SADA can accept map layers from a Geographic Information System (GIS) saved in a Data eXchange Format (DXF), Shape File Format (shp) or as a variety of raster formats including JPEG, GIF, and TIFF. Multiple layers can be imported into SADA, and the user can control the layer order and coloring scheme. In addition, the user can select a sub-region of the site to direct an analysis. This user-defined polygon will only consider data points within (or without) the interior of the delimited region when performing the analyses. If you don't have any GIS type data, it's ok. SADA's functionality does not require these files and there is no reduction in capabilities.

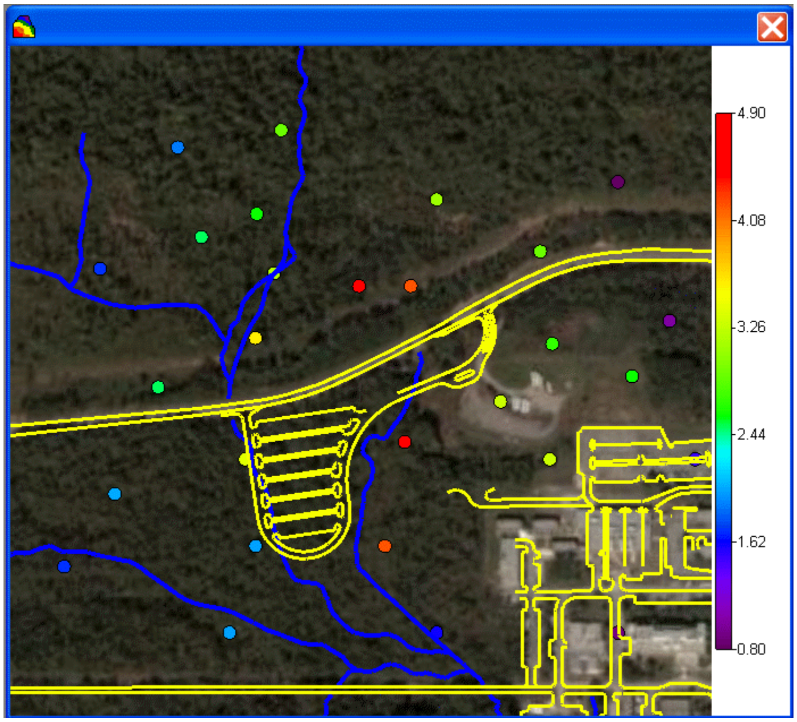

Figure 1. Example of SADA version 5 GIS mapping visualization.

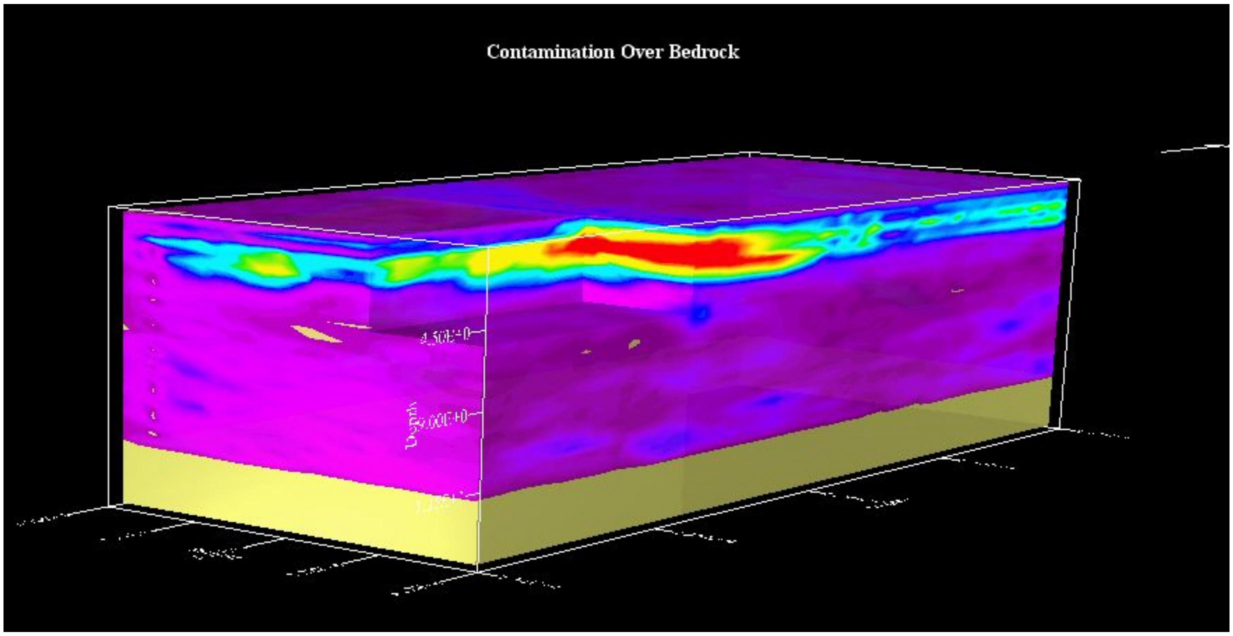

Figure 2. Example of SADA version 5 3-D visualization.

SADA version 6 presents modern 2 and 3-D visualization as can be seen in Figure 3. The addition of surface elevation provides even greater realism as seen in Figure 4.

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Figure 3. SADA version 6 modern GIS infrastructure.

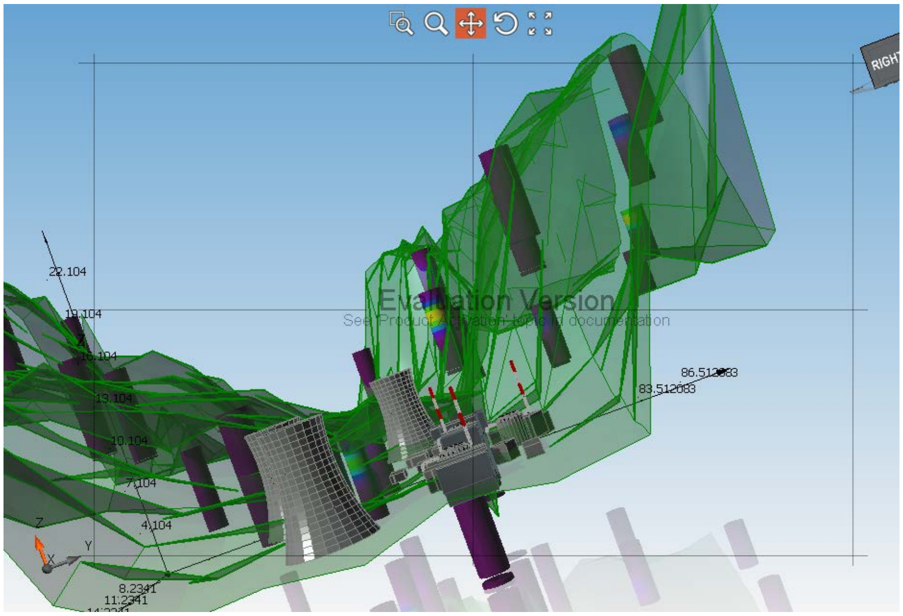

Figure 4. SADA version 6 modern 3-D visualization.

The human health risk assessment tools for chemicals in SADA will be upgraded to include assessment of mutagens and the trichloroethylene (TCE) specific models. Equations 1 through 3 present the mutagen equations for residential exposure to soil. Equations 4 through 6 present the equations for TCE residential exposure to soil. Similar equations are used for exposure to groundwater.

The human health risk assessment tools for radionuclides in SADA will be upgraded to include assessment of the construction worker, more biota choices (swine, eggs, poultry) for the farmer and exposure to contaminated game and fowl for the recreator scenario. In addition, new area correction factors (ORNL 2014a) and soil gamma shielding factors (ORNL 2014b) are now available on an isotope-specific and source depth specific basis. Finally the latest slope factors will be incorporated from ORNL (ORNL 2014c)

Equation 1. Residential Soil Ingestion for Mutagens.

$$SL_{res\text{-}soil\text{-}mu\text{-}ing}\,(mg/kg)=\frac{TR\times AT_{ress}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times IFSM_{res\text{-}adj}\left(\frac{166833.33\ mg}{kg}\right)\times\left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$IFSM_{res\text{-}adj}\left(\frac{166833.33\ mg}{kg}\right)=\left(\begin{array}{l}\frac{EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times ED_{0\text{-}2}\,(years)\times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right)\times 10}{BW_{0\text{-}2}\,(15\ kg)}+\frac{EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times ED_{2\text{-}6}\,(years)\times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right)\times 3}{BW_{2\text{-}6}\,(15\ kg)}+\\ \frac{EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times ED_{6\text{-}16}\,(years)\times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right)\times 3}{BW_{6\text{-}16}\,(80\ kg)}+\frac{EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times ED_{16\text{-}26}\,(years)\times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right)\times 1}{BW_{16\text{-}26}\,(80\ kg)}\end{array}\right)$$

Equation 2. Residential Soil Dermal Contact for Mutagens.

$$SL_{res\text{-}soil\text{-}mu\text{-}der}\,(mg/kg)=\frac{TR\times AT_{ress}\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFSM_{res\text{-}adj}\left(\frac{428260\ mg}{kg}\right)\times ABS_d\times\left(\frac{10^{-6}kg}{mg}\right)}$$

where:

$$DFSM_{res\text{-}adj}\left(\frac{428260\ mg}{kg}\right)=\left(\begin{array}{l}\frac{EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times ED_{0\text{-}2}\,(years)\times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right)\times SA_{0\text{-}2}\left(\frac{2373\ cm^2}{day}\right)\times 10}{BW_{0\text{-}2}\,(15\ kg)}+\\ \frac{EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times ED_{2\text{-}6}\,(years)\times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right)\times SA_{2\text{-}6}\left(\frac{2373\ cm^2}{day}\right)\times 3}{BW_{2\text{-}6}\,(15\ kg)}+\\ \frac{EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times ED_{6\text{-}16}\,(years)\times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right)\times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right)\times 3}{BW_{6\text{-}16}\,(80\ kg)}+\\ \frac{EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times ED_{16\text{-}26}\,(years)\times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right)\times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right)\times 1}{BW_{16\text{-}26}\,(80\ kg)}\end{array}\right)$$

Equation 3. Residential Soil Inhalation for Mutagens.

$$SL_{res\text{-}soil\text{-}mu\text{-}inh}\left(mg/kg\right)=\frac{TR\times AT_{ress}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}{IUR\left(\frac{\mu g}{m^{3}}\right)^{-1}\times\left(\frac{1}{VF_{s}\left(\frac{m^{3}}{kg}\right)}+\frac{1}{PEF_{w}\left(\frac{m^{3}}{kg}\right)}\right)\times\left(\frac{1000\ \mu g}{mg}\right)\times\left(\begin{array}{l}\left(ET_{0\text{-}2}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times ED_{0\text{-}2}\left(years\right)\times 10\right)+\\ \left(ET_{2\text{-}6}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times ED_{2\text{-}6}\left(years\right)\times 3\right)+\\ \left(ET_{6\text{-}16}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times ED_{6\text{-}16}\left(years\right)\times 3\right)+\\ \left(ET_{16\text{-}26}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times ED_{16\text{-}26}\left(years\right)\times 1\right)\end{array}\right)}$$

Equation 4. Residential Soil Ingestion for TCE.

$$SL_{res\text{-}soil\text{-}tce\text{-}ing}\left(mg/kg\right)=\frac{TR\times AT_{ress}\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}{CSF_{o}\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times\left(\frac{10^{-6}kg}{mg}\right)\times\left(\begin{array}{l}\left(CAF_{o}\left(0.804\right)\times IFS_{res\text{-}adj}\left(\frac{37650\ mg}{kg}\right)\right)+\\ \left(MAF_{o}\left(0.202\right)\times IFSM_{res\text{-}adj}\left(\frac{166833.33\ mg}{kg}\right)\right)\end{array}\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{36750\ mg}{kg}\right)=\left(\begin{array}{l}\frac{ED_{ressc}\left(6\ years\right)\times EF_{ressc}\left(\frac{350\ days}{year}\right)\times IRS_{ressc}\left(\frac{200\ mg}{day}\right)}{BW_{ressc}\left(15\ kg\right)}+\\ \frac{\left(ED_{ress}\left(26\ years\right)-ED_{ressc}\left(6\ years\right)\right)\times EF_{ressa}\left(\frac{350\ days}{year}\right)\times IRS_{ressa}\left(\frac{100\ mg}{day}\right)}{BW_{ressa}\left(80\ kg\right)}\end{array}\right)$$

where:

$$IFSM_{res\text{-}adj}\left(\frac{166833.33\ mg}{kg}\right)=\left(\begin{array}{l}\frac{ED_{0\text{-}2}\left(2\ years\right)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right)\times 10}{BW_{0\text{-}2}\left(15\ kg\right)}+\\ \frac{ED_{2\text{-}6}\left(4\ years\right)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right)\times 3}{BW_{2\text{-}6}\left(15\ kg\right)}+\\ \frac{ED_{6\text{-}16}\left(10\ years\right)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right)\times 3}{BW_{6\text{-}16}\left(80\ kg\right)}+\\ \frac{ED_{16\text{-}26}\left(10\ years\right)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right)\times 1}{BW_{16\text{-}26}\left(80\ kg\right)}\end{array}\right)$$

Equation 5. Residential Soil Dermal Contact for TCE.

$$SL_{res\text{-}soil\text{-}tce\text{-}der}\,(mg/kg)=\frac{TR\times AT_{ress}\left(\frac{365\text{ days}}{\text{year}}\times LT\,(70\text{ years})\right)}{\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times\left(\frac{10^{-6}kg}{mg}\right)\times\left(\left(CAF_o\,(0.804)\times DFS_{res\text{-}adj}\left(\frac{103390\text{ mg}}{kg}\right)\times ABS_d\right)+\left(MAF_o\,(0.202)\times DFSM_{res\text{-}adj}\left(\frac{428260\text{ mg}}{kg}\right)\times ABS_d\right)\right)}$$

where:

$$DFS_{res\text{-}adj}\left(\frac{1103390\text{ mg}}{kg}\right)=\left(\frac{ED_{ressc}\,(6\text{ years})\times EF_{ressc}\left(\frac{350\text{ days}}{\text{year}}\right)\times SA_{ressc}\left(\frac{2373\text{ cm}^2}{\text{day}}\right)\times AF_{ressc}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right)}{BW_{ressc}\,(15\text{ kg})}+\frac{\left(ED_{ress}\,(26\text{ years})-ED_{ressc}\,(6\text{ years})\right)\times EF_{ressa}\left(\frac{350\text{ days}}{\text{year}}\right)\times SA_{ressa}\left(\frac{6032\text{ cm}^2}{\text{day}}\right)\times AF_{ressa}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right)}{BW_{ressa}\,(80\text{ kg})}\right)$$

where:

$$DFSM_{res\text{-}adj}\left(\frac{428260\text{ mg}}{kg}\right)=\left(\begin{array}{l}\frac{ED_{0\text{-}2}\,(2\text{ years})\times EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right)\times AF_{0\text{-}2}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right)\times SA_{0\text{-}2}\left(\frac{2373\text{ cm}^2}{\text{day}}\right)\times 10}{BW_{0\text{-}2}\,(15\text{ kg})}+\\ \frac{ED_{2\text{-}6}\,(4\text{ years})\times EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right)\times AF_{2\text{-}6}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right)\times SA_{2\text{-}6}\left(\frac{2373\text{ cm}^2}{\text{day}}\right)\times 3}{BW_{2\text{-}6}\,(15\text{ kg})}+\\ \frac{ED_{6\text{-}16}\,(10\text{ years})\times EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times AF_{6\text{-}16}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right)\times SA_{6\text{-}16}\left(\frac{6032\text{ cm}^2}{\text{day}}\right)\times 3}{BW_{6\text{-}16}\,(80\text{ kg})}+\\ \frac{ED_{16\text{-}26}\,(10\text{ years})\times EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times AF_{16\text{-}26}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right)\times SA_{16\text{-}26}\left(\frac{6032\text{ cm}^2}{\text{day}}\right)\times 1}{BW_{16\text{-}26}\,(80\text{ kg})}\end{array}\right)$$

Equation 6. Residential Soil Inhalation for TCE.

$$SL_{res\text{-}soil\text{-}tce\text{-}inh}\,(mg/kg)=\frac{TR\times AT_{ress}\left(\frac{365\text{ days}}{\text{year}}\times LT\,(70\text{ years})\right)}{\begin{array}{c}IUR\left(\mu g/m^3\right)^{-1}\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)\times\left(\frac{1000\,\mu g}{mg}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times\\ \left(\left(\begin{array}{l}CAF_i\,(0.756)\times EF_{ress}\left(\frac{350\text{ days}}{\text{year}}\right)\times\\ ED_{ress}\,(26\text{ years})\times ET_{ress}\left(\frac{24\text{ hours}}{\text{day}}\right)\end{array}\right)+\left(\begin{array}{l}\left(ED_{0\text{-}2}\,(2\text{ years})\times EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{0\text{-}2}\left(\frac{24\text{ hours}}{\text{day}}\right)\times MAF_i\,(0.244)\times 10\right)+\\ \left(ED_{2\text{-}6}\,(4\text{ years})\times EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{2\text{-}6}\left(\frac{24\text{ hours}}{\text{day}}\right)\times MAF_i\,(0.244)\times 3\right)+\\ \left(ED_{6\text{-}16}\,(10\text{ years})\times EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{6\text{-}16}\left(\frac{24\text{ hours}}{\text{day}}\right)\times MAF_i\,(0.244)\times 3\right)+\\ \left(ED_{16\text{-}26}\,(10\text{ years})\times EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times ET_{16\text{-}26}\left(\frac{24\text{ hours}}{\text{day}}\right)\times MAF_i\,(0.244)\times 1\right)\end{array}\right)\right)\end{array}}$$

DISCUSSION

The EPA currently has a need for a standardized human health risk assessment tool that can be used by staff to produce baseline and site-specific risk assessments. SADA was developed by EPA and is well established in the risk community. It is capable of handling the 4 major parts of a risk assessment: data analysis, exposure assessment, toxicity assessment and risk characterization. In addition, SADA has many tools for providing decision assistance in reaching site risk goals. At the time of SADA's last release, it was current with most of EPA's human health risk guidance. While SADA is currently producing technically valid and defensible risk assessments, it is not doing so with the latest guidance from EPA. Since the last release, SADA is in need of some upgrades in its risk modules. These upgrades are listed below by the four categories previously mentioned plus a SADA-wide category. These upgrades span chemical and radionuclide analysis.

DATA ANALYSIS

One of the most powerful features of SADA is that it can handle all the environmental data from a site through the entire risk assessment process. The standard media of soil, groundwater, sediment and surface water are integrated into the code. Additional media can be assessed with the Custom Analysis mode. Specific suggested upgrades are listed below:

Exposure Point Concentration (EPC). SADA currently determines the EPC by multiple methods involving maximum, average and UCL95 decisions. The UCL95 determination in SADA will be upgraded to include the ProUCL95 distribution determination methods.

EXPOSURE ASSESSMENT

SADA currently provides the ability to assess risk and develop screening levels for resident, worker, farmer, recreator and excavation/construction worker. Each of these landuses can be modified for a specific purpose like a trespasser scenario. All of the exposure parameters can be edited. Exposure assessment additions are listed below:

Indoor Worker. A separate indoor worker scenario will be added because the current worker scenario is geared for outdoor worker.

Composite Worker. Currently the RSLs and radionuclide calculators combine the most protective aspects of the indoor and outdoor worker. The composite worker will be added.

Tapwater. SADA is upgraded to follow RAGS Part E guidance for dermal exposure to tapwater.

TOXICITY ASSESSMENT

SADA allows the user to use media-specific toxicity values. This is important for some chemicals but mainly for radionuclides that have multiple oral slope factors (soil, water, food). SADA also allows the user to change any of the toxicity or chemical-specific parameters. Toxicity assessment needs are listed below.

Mutagens. Currently SADA provides standard adult and child age groups but needs to have the 4 age groups required to do the mutagen analysis.

Vinyl Chloride(VC). VC has its own special mutagen equations that need to be incorporated.

Trichloroethylene (TCE). TCE has its own special mutagen equations that need to be incorporated.

Metadata. The toxicity metadata is not currently provided in SADA output. It will be added.

RISK CHARACTERIZATION

SADA not only provides the ability generate screening values but also can do “forward” risk that gives the cancer and hazard risks for each landuse and media. Once all the exposure assessment needs are met, the forward risk component will be current.

SADA-WIDE

There a few items being added to SADA to make the documentation of the risk calculations standardized.

RAGS Part D. SADA has a powerful auto-documentation feature that allows the user to save every step of the risk assessment process from start to finish. These steps can be printed and conveniently provide the framework for a risk assessment report. The auto-documentation feature will be upgraded to provide the output in RAGS Part D compatible format to minimize post-processing of tables by the user.

DATA Minimization. While SADA can handle an entire environmental data set, it will now automatically reduce the dataset after each screen to determine contaminants of potential concern (COPCs). These analytes that are screened out will then be listed in the auto-documentation. SADA currently provides a tool for the user to manually exclude analytes.

Radionuclides vs Chemicals. Currently SADA allows the user to mix chemicals and radionuclides in one database and sum risk across both. With the developments of recent years (RAGS Part E and F) it is time to separate the chemical from radionuclide risk.

Radionuclides. Multiple exposure routes have been added to the EPA radionuclide PRG calculator and should be added to SADA. These are: Immersion, Submersion, groundplane and soil volumes for 1, 5 and 15cm depths. Also the radionuclide slope factors are now being provided for multiple age groups and genders. SADA should be ready for this transition. A further option of allowing the user to switch from pCi to Bq would be useful.

Toxicity Values. SADA is being developed in conjunction with the same toxicity and parameter databases used for the EPA chemical and radionuclide web-based calculator tools. Every update to an EPA tool will generate a new database for upload into SADA.

CONCLUSIONS

The improvements to SADA version 6 2-D and 3-D visualization platforms will make SADA compatible with the state of the art modeling environments. The improvements to SADA version 6 chemical human health risk assessment models will essentially make SADA a corollary to the EPA Regional Screening Levels (EPA 2015a). The improvements to SADA version 6 radionuclide human health risk assessment models essentially make SADA a corollary to the EPA Superfund Radionuclide Preliminary Remediation Goals for Radionuclides (PRG) website (EPA 2015b). The integration of the EPA toxicity and parameter sources into the SADA project will keep SADA current for years to come.

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