Ranking Methods for Pesticide Prioritization

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Abstract

Results from comparative ecological risk assessments can be used along with other MDH drinking water assessments, in consultation with other State Agencies, to assess and rank relatively large numbers of pesticides for prioritization of full MDH drinking water assessments. Risk Quotients (RQs) based on toxicity and exposure data for ten hypothetical pesticides (insecticides, fungicides, and herbicides) were used to demonstrate a four-step risk ranking procedure. Results from drinking water and ecological risk assessments are provided in Tables 1 and 2. These RQs are given weighted scores based on their relative drinking water and ecological risk (Table 3). The risk scores for each pesticide are then ranked (Table 4) and the results are demonstrated graphically to facilitate the evaluation of relative risk among the ten pesticides (Figures 1 – 3). The results show that Pesticide D poses the highest combined drinking water and ecological risk. Pesticide A poses the second highest risk, and so on. These methods provide a relatively rapid and informative way to assess and rank overall risk posed by pesticides.

Methods

Table 1. Drinking Water Risk Quotient (RQ) Summary

Hypothetical pesticide	Lowest Health based value	Maximum residue detection level	RQ (maximum detection/ guidance value)
Pesticide A	0.45 ug/L	5.0 ug/L	11
Pesticide B	0.33 ug/L	0.1 ug/L	0.3
Pesticide C	111 ug/L	1.0 ug/L	0.009
Pesticide D	0.004 ug/L	0.7 ug/L	170
Pesticide E	0.13 ug/L	0.2 ug/L	1.5
Pesticide F	17 ug/L	0.05 ug/L	0.003
Pesticide G	2500 ug/L	2.5 ug/L	0.001
Pesticide H	0.018 ug/L	0.007 ug/L	0.4
Pesticide I	25 ug/L	0 (no detections)	0
Pesticide J	0.01 ug/L	0 (no detections)	0

Table 2. Ecological Risk Quotient (RQ) Summary

Hypothetical Pesticide	Aquatic Organism RQ		Terrestrial Organism RQ	Aquatic Plant RQ	
	Calculated Using Aquatic EEC	Calculated Using Max. Detection Value	Calculated Using Terrestrial EEC	Calculated Using Aquatic EEC	Calculated Using Max. Detection Value
Pesticide A	8.9	3.3	4.4	14	11
Pesticide B	310	120	221	62	4.0
Pesticide C	0.3	0.001	0.001	0.7	0.6
Pesticide D	6100	15	4.8	7.6	0.02
Pesticide E	315	1.5	492	15	5.0
Pesticide F	2.4	0.2	0.2	0.1	0.3
Pesticide G	311	4.0	341	0.001	0.001
Pesticide H	0.05	0.04	0.001	205	115
Pesticide I	0.04	0 (no detection)	9.5	0.05	0 (no detection)
Pesticide J	0.001	0 (no detection)	0.002	1.2	0 (no detection)

Hypothetical toxicity and exposure date were used to calculate the Risk Quotients (RQs) provided in Tables 1 and 2. These estimated data were based generally on results from USEPA laboratory toxicity studies , MDA environmental monitoring data, and Estimated Environmental Concentrations (EECs) using EPA methods. Pesticides were given risk scores based on where their RQs fall within a series of ranges (Table 3.). Drinking water RQs ranged up to 128 and received a risk score from 0 to 11 (based on ranges separated by a factor of 2). Ecological RQs ranged up to > 1000 and received a risk score from 0 to 7 (based on ranges separated by a factor of 10). In this way, drinking water risk was weighted more heavily than ecological risk in order to facilitate interpretation of the data without effecting relative risk ranking among the pesticides (Figures 1 - 3). Table 4 provides pesticide risk ranking for drinking water and ecological effects. These data are provided graphically in Figures 1 – 3. Figure 1 shows relative drinking water risk among the ten pesticides. Pesticide D poses the highest risk. Pesticides I and J do not demonstrate drinking water risk because they have not been detected in surface water or groundwater. Figure 2 shows additive ecological risk based on RQs for aquatic plants, terrestrial organisms (such as birds), and aquatic organisms (such as fish and aquatic invertebrates). Finally, Figure 3. provides a comparison of risk among pesticide taking into account both drinking water risk and risk to aquatic organisms.

Table 3. Drinking Water and Ecological Risk Scores

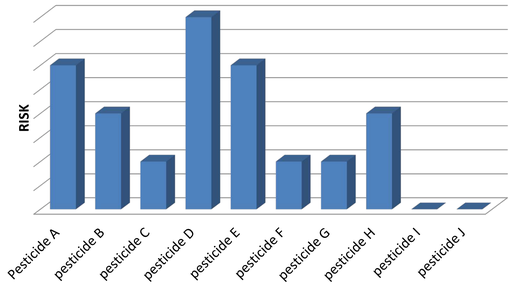
Drinking Water Risk		Ecological Risk	
Range of Risk Quotients	Score	Range of Risk Quotients	Score
No environmental detections	0	No environmental detections	0
>0 to 0.25	1	>0 to 0.01	1
>0.25 to 0.5	2	>0.01 to 0.1	2
>0.5 to 1.0	3	>0.1 to 1.0	3
>1.0 to 2.0	4	>1.0 to 10	4
>2.0 to 4.0	5	>10 to 100	5
>4.0 to 8.0	6	>100 to 1000	6
>8.0 to 16	7	>1000	7
>16 to 32	8		
>32 to 64	9		
>64 to 128	10		
>128	11		

Table 4. Risk Ranking for Drinking Water and Ecological Effects (11 is highest risk)

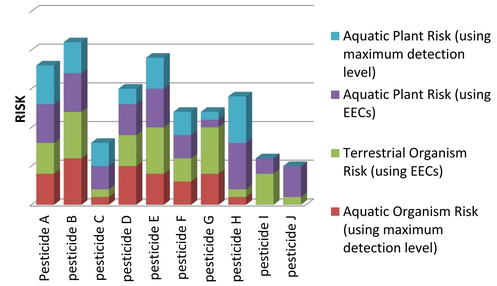
Hypothetical pesticide	Drinking water risk characterization, based on maximum detection level (RQ)	Ecological risk characterization				
		Aquatic organisms		Terrestrial organisms	Aquatic plants	
		Based on EEC (RQ)	Based on max. detect level (RQ)	Based on EEC (RQ)	Based on EEC (RQ)	Based on max. detect level (RQ)
Pesticide A (Herbicide)	7 (11.0)	4 (8.9)	4 (3.3)	4 (4.4)	5 (14)	5 (11)
Pesticide B (Herbicide)	2 (0.3)	6 (310)	6 (120)	6 (221)	5 (62)	4 (4.0)
Pesticide C (Insecticide)	1 (0.009)	3 (0.3)	1 (0.001)	1 (0.001)	3 (0.7)	3 (0.6)
Pesticide D (Fungicide)	11 (170)	7 (6,100)	5 (15)	4 (4.8)	4 (7.6)	2 (0.02)
Pesticide E (Herbicide)	4 (1.5)	6 (315)	4 (1.5)	6 (492)	5 (15)	4 (5.0)
Pesticide F (Herbicide)	1 (0.003)	4 (2.4)	3 (0.2)	3 (0.2)	3 (0.1)	3 (0.3)
Pesticide G (Insecticide)	1 (0.001)	6 (311)	4 (4.0)	6 (341)	1 (0.001)	1 (0.001)
Pesticide H (Herbicide)	2 (0.4)	2 (0.05)	1 (0.04)	1 (0.001)	6 (205)	6 (115)
Pesticide I (Fungicide)	0 (no detects)	2 (0.04)	0 (no detects)	4 (9.5)	2 (0.05)	0 (no detects)
Pesticide J (Herbicide)	0 (no detects)	1 (0.001)	0 (no detects)	1 (0.002)	4 (1.2)	0 (no detects)

Results

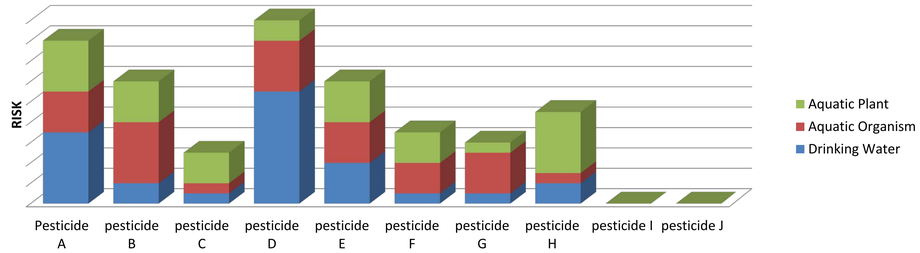
Comparative Drinking Water Risk
Figure 1.



Comparative Ecological Risk
Figure 2.



Comparative Drinking Water and Ecological Risk (based on maximum environmental detection levels)
Figure 3.



Discussion

Table 5. Comprehensive Risk Ranking (1 is highest risk, 10 is lowest risk)

Overall risk ranking	Hypothetical pesticide	Justification for ranking order
1	Pesticide D	Highest overall risk ranking because it poses the highest drinking water risk (figure 1).
2	Pesticide A	Ranked second highest because it poses the second highest drinking water risk (figure 1).
3	Pesticide E	Ranked third highest because it poses the third highest drinking water risk (figure 1).
4	Pesticide B	Ranked fourth highest because it poses approximately the same drinking water risk as pesticide H, but it has a higher ecological risk (figure 3).
5	Pesticide H	Ranked fifth highest because it poses a higher drinking water risk than pesticide C, pesticide F, and pesticide G (figure 2 and figure 3).
6	Pesticide F	Ranked sixth highest because it poses a low drinking water risk but it has a high ecological risk (figure 2 and figure 3).
7	Pesticide G	Ranked seventh highest because it poses a higher ecological risk than pesticide C (figure 3).
8	Pesticide C	Ranked eighth highest because it poses a low drinking water risk and a relatively low ecological risk (figure 3).
9	Pesticide I	Ranked ninth highest because although there are no environmental detections, it poses a high ecological risk to terrestrial organisms based on EECs (figure 2).
10	Pesticide J	Lowest overall risk ranking of the 10 pesticides because there are no environmental detections and it poses a relatively low ecological risk based on EECs (figure 2).

Conclusions

Pesticides A and D are ranked highest in overall risk because they pose the highest drinking water risk. Pesticides B, E, H are in the mid-range of overall risk estimates because they pose a relatively high drinking water risk and a relatively high ecological risk. Pesticides C, F, and G pose a lower estimated risk because they pose a lower drinking water and ecological risk. Pesticide I and J have the lowest risk because they have not been detected in surface water or groundwater. These ranking methods provide a useful way to rapidly evaluate drinking water risk and ecological risk of pesticides, and to combine them into an overall risk estimate. This allows for a large number of pesticides to be efficiently ranked and prioritized for full drinking water assessments. Results from this comprehensive risk ranking assessment may also prove to be useful in evaluating overall risk trends as pesticide use patterns change over time.