应用技术

模糊综合评判法在矿区地下水水质评价中的应用

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摘　要:为了对矿区地下水水质作更合理的评价 ,在分析矿区水质特点的基础上 ,选取酚、氰等评价因子 ,从主客观两方面相结合对评价因子权值做了适当的选择 ,采用模糊综合评判法对某矿区的地下水水质进行了符合实际的评价 ,并提出了防止水质继续恶化的几点建议。

关键词:矿井地下水;水质;评价因子;权重;模糊综合评判

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煤炭资源的开发和利用 ,对国民经济的发展起到了巨大的推动作用 ,但对环境造成了较大影响 ,矿区的地下水资源遭到了人为采动破坏和污染 ,使矿区的饮水出现问题。是否需要开辟新的水源就必须对其水质作出客观的评价。由于水质综合评价中的污染程度、水质类别都是一些客观存在的模糊概念和模糊现象 ,因此用模糊集理论进行水质评价 ,更能客观地反映水质的实际状况。

1　模糊综合评判原理[1]

模糊综合评判可以用一数学式来表示: $B = A \cdot R$,其中 A 是由参加评价因子的权重经归一化处理得到的一个 $1 \times N$ 阶权重模糊行矩阵; R 是由各单因子评价行矩阵组成的一个 $N \times M$ 阶模糊关系矩; B 是一个 $1 \times M$ 阶矩阵 ,是综合评判结果。

2　矿区地下水水质的模糊综合评判

2.1　评价指标及标准的选择

由于矿区的特点决定了矿区地下水的污染以煤矿开采为主 ,兼有农业生产和居民生活等方面因素共同作用造成的[2]。为全面反映矿区地下水的污染基本情况 ,对其矿区实测的 4 个水样点(如表 1 所示)进行毒理学评价 ,选取酚、氰、氟、COD、三氮、硬度、矿化度 8 个评因子 ,组成评价因子集合 $U = \{$酚、氰、氟、COD、三氮、硬度、矿化度$\}$,其中硬度和矿化度为综合指标。本评价采用国家技术监督局 1990 年 1 月 1 日发布的《地下水质量标准》进行。在考虑区域本底浓度值的基础上将该矿区地下水分为 5 个级别 ,组成水质分级集合 $V = \{$ Ⅰ, Ⅱ, Ⅲ, Ⅳ, Ⅴ$\}$。其中 Ⅰ、Ⅱ级水主要反映地下水化学组成的天然背景含量 ,适用于各种用途; Ⅱ级水以人体健康基值为依据 ,主要适用于集中式生活饮用水源及工业、农业用水; Ⅳ级水以农业和工业用水要求为依据 ,除适用于农业和部分工业用水外 ,适当处理后可作生活饮用水; Ⅴ级水不宜饮用。分级标准见表 2。

表 1　水样水质分析数据　　mg/L

序号	酚	氰	氟	COD	三氮	氯	硬度	矿化度
1	0.05	0.002 0	1.09	6.97	10.08	33.36	175.33	381.36
2	0	0.002 1	0.30	1.74	12.04	310.26	884.66	1 117.20
3	0	0.000 5	0.30	2.85	11.13	372.24	659.49	1 127.80
4	0.08	0.001 3	0.25	1.65	4.83	55.35	306.69	803.80

表 2　地下水水质分级标准　　mg/L

水质分级	酚	氰	氟	COD	三氮	氯	硬度	矿化度
Ⅰ	0.000 1	0.001	0.1	1.0	10	125	180	400
Ⅱ	0.001	0.02	0.5	1.5	30	185	270	600
Ⅲ	0.002	0.05	1.0	2.5	45	250	450	1 000
Ⅳ	0.005	0.1	1.5	4.5	100	500	900	2 000
Ⅴ	0.01	0.2	2.0	6.5	200	1 250	1 800	3 000

2.2　计算隶属度进行单因子评价

样本对于各级水质的隶属程度是用隶属度来刻划的 ,隶属函数 $r_{ij}(x)$ 表示实测浓度 x 与其相对应的第 i 个评价因子对第 j 级水质的隶属度 ,它只能在 $[0,1]$ 区间连续取值 ,即 $0 \leq r_{ij}(x) \leq 1$,以隶属度表达隶属资格时 ,隶属度数值愈大 ,隶属资格愈高。采用一次型作为隶属函数模型 ,当地下水实测浓度 x 小于等于 j 级地下水标准浓度时 ,其隶属度取 1;当地下水实测浓度 x 大于等于 $j+1$ 级地下水标准浓度时 ,其隶属度取 0;介于 j 与 $j+1$ 级地下水标准浓度

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者,其隶属度按线性内插法确定,即:$C_{ij} \leq x \leq C_{ij+1}$ 时,取

$$r_{ijk} = \frac{C_{ij+1} - x}{C_{ij+1} - C_{ij}};\ r_{ij+1} = \frac{x - C_{ij}}{C_{ij+1} - C_{ij}}$$

2.3　建立模糊关系矩阵

按分类组成的单因素评价矩阵,即:

$$R = [\,r_{ij}\,] = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}$$

由此可得到 2 号水样点的模糊关系矩阵:

$$R = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.94 & 0.06 & 0 & 0 & 0 \\ 0.50 & 0.45 & 0 & 0 & 0 \\ 0 & 0.76 & 0.24 & 0 & 0 \\ 0.90 & 0.10 & 0 & 0 & 0 \\ 0 & 0 & 0.76 & 0.24 & 0 \\ 0 & 0 & 0.01 & 0.99 & 0 \\ 0 & 0 & 0.88 & 0.12 & 0 \end{bmatrix}$$

2.4　建立权重模糊矩阵

为了更客观的选择权重,采用国家饮用水标准和主观分析相结合的方法,即根据水质指数 C_i / C_{oi} (C_i 为实测值,C_{oi} 国家饮用水标准)的大小来确定权重,因为采用饮用水标准已经考虑了各评价参数对人体的危害程度。酚类和氰化物都是毒性很强的物质,在剂量不大的情况下,其致害作用长且具有可逆性,这两种组分都不稳定,在酸性条件下容易挥发,天然状况下容易自净;地下水中氟含量过高,长期饮用可引起氟病的发生;硬度和矿化度是综合指标,其值过大对人体的危害是很大的。COD、三氮及氯长期过量摄入对人体健康具有潜在的危害。因此把这 8 种参数权序由大到小确定为:氟、硬度、酚、矿化度、氰、COD、三氮、氯。考虑以上因素,得到两个模糊权重集 α 和 β,他们是 U 上的模糊子集。

$$\alpha = [\alpha_1 \quad \alpha_2 \quad \alpha_3 \quad \alpha_4 \quad \alpha_5 \quad \alpha_6 \quad \alpha_7 \quad \alpha_8]$$

$$\beta = [\beta_1 \quad \beta_2 \quad \beta_3 \quad \beta_4 \quad \beta_5 \quad \beta_6 \quad \beta_7 \quad \beta_8]$$

$$\alpha_i = \frac{C_i / S_i}{\sum_{i=1}^{8} C_i / S_i}$$

式中　C_i ——各评价因子的实测值;

S_i ——每个因子所对应的各个水质级别的判别值之和的平均值;

β_i ——根据以上分析所得到的权重序列人为给予的数值,且 $\sum \beta_i = 1$。

$\beta_i = [0.15 \quad 0.10 \quad 0.25 \quad 0.05 \quad 0.05 \quad 0.20 \quad 0.15]$

求模糊集的代数积,归一化后得到修正的模糊矩阵为

$$A_i = \frac{\alpha_i \cdot \beta_i}{\sum_{i=1}^{8} (\alpha_i \cdot \beta_i)}$$

由此可得到 2 号水样点的权值模糊矩阵为

$A = [0 \quad 0.006 \quad 0.144 \quad 0.053 \quad 0.015 \quad 0.065 \quad 0.481 \quad 0.235]$

2 号样点水质评价权重计算结果见表 3。

表 3　2 号样点权重计算表

评价因子	酚	氰	氟	COD	三氮	氯	硬度	矿化度
C_i	0	0.0021	0.3	1.74	12.042	310.26	884.66	1117.20
S_i	0.00362	0.0742	1.02	3.2	77	462	720	1400
C_i / S_i	0	0.0283	0.294	0.543	0.156	0.671	1.229	0.798
a_i	0	0.008	0.079	0.146	0.042	0.180	0.330	0.215
b_i	0.15	0.10	0.25	0.05	0.05	0.05	0.20	0.15
A_i	0	0.006	0.144	0.053	0.015	0.065	0.481	0.235

2.5　综合评判结果

求评价结果是通过 A 与 R 复合运算 $A \cdot R$ 完成的,这实际上是对各评价因子进行加权的过程。模糊矩阵复合运算非常类似普通矩阵的乘法,所不同的是,复合运算在模糊数学里是通过模糊算子进行的,这里采用的模糊算子是:

$$b_j = \bigvee_{i=1}^{5} (a_j \wedge r_{ij}) \qquad (j = 1, 2 \cdots 8)$$

对于 2 号水样点 $B_2 = [0.144 \quad 0.144 \quad 0.235 \quad 0.481 \quad 0.000]$,隶属度 0.481 对应 Ⅳ级水,根据最大的隶属度原则确定 2 号水样点水质为 Ⅳ级。若在评价结果中出现两个最大值,采取靠近次大值的那个最大值来确定级别。同样的方法可得到 1、3 和 4 号水样的级别:

$B_1 = [0.019 \quad 0.003 \quad 0.105 \quad 0.105 \quad 0.812]$, Ⅴ级;

$B_3 = [0.105 \quad 0.105 \quad 0.413 \quad 0.413 \quad 0.000]$, Ⅳ级;

$B_4 = [0.017 \quad 0.024 \quad 0.024 \quad 0.000 \quad 0.925]$, Ⅴ级。

通过以上分析,说明该矿区地下水污染比较严重,已不能作为饮用水水源。

3　结论

1) 模糊综合评判在矿区地下水水质评价中的应用,关键在于评价因子的选择,作者选用酚、氰、氟、矿化度等是合适的。

2) 模糊综合评判方法在矿区地下水水质评价中的应用,评价结果合理、可信。该方法减少了人为因素的干扰,取得了满意的效果。

3) 由评价结果可知该矿区的地下水污染比较严重,建议立即采取治理措施。

4 几点建议

地下水一旦受污染,要进行处理很困难,所以要以防为主,防治结合为原则,矿区地下水的污染主要以煤炭开采和相关厂矿的工业污染为主。针对这一特点,提出以下几点建议,防止开采引起地下水污染:

1)对堆放煤矸石和粉煤灰的场地进行防渗处理,消除地面污染源。对矿井水、工业废水及居民生活废水进行处理,达到国家污水排放标准后排放。

2)在含水层与矿坑水联系密切的地方建立反渗透帷幕,防止地下水流入矿坑或井巷。对塌陷的地质构造形成的含水层及井巷导水通道,采用回填、注浆方法封堵。

3)超前开采利用疏干水,对即将被疏干或破坏的含水层,选择合适的疏干方式,充分利用或储存疏干水,选择合理的开采方法和措施保护水资源,减轻开采对水体的破坏和污染。

4)及时整治由矿山开采造成的大面积地面塌陷,复土造田,恢复原貌,不能恢复的,可以利用塌陷湖发展养殖业,用以改善积存的水质,避免引起地下水水质的恶化。

5)加强地下水水质、水量的动态监测工作。

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能源,不断提高能源利用效率。

3)加强政府的宏观调控,完善市场导向的能源体制。政府应从国家利益、社会环境利益出发制定政策、规划、法规、标准,以及经济杠杆来引导企业和全社会重视能源事业的发展;大力开发利用新能源和可再生能源,政府的支持是发展可再生能源的关键。

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English Abstracts of This Issue

Research on Coal - bed Gas Emission and Emission Intensity in Working Faces (1) - Based on Darcy's law, the formula used for the calculation of gas emission volume and intensity has been derived, in which the change of ventilation coefficient that is affected by coal mining has been taken into consideration. Base upon that, the solution bas been made by the computer, and the chart of relationship among the gas emission volume, emission intensity, gas pressure, mining time and the distance to the ribs in front of the working face has been plotted out in this paper.

Digitized Construction of Mineral Resources (4) - Information is the megatrends of the development of the global economy and society nowadays. Database is the key factor for the construction of mineral resources MapGIS. This thesis mainly introduces the issues of the mineral resources' digitization based on the MapGIS.

Effect of Methane on Global Warming and Mitigating Measures (6) - The content of greenhouse gases has been increased with the double of the world population and human activities. Global warming becomes a more popular topic problem. Greenhouse effect of methane is only inferior to carbon dioxide. At present the total discharge volume of methane to the air is 5.35×10^8 t, about 3.75×10^8 t due to the human activities. In this paper, the authors expounded the mechanism and function of methane to the greenhouse effect and the meaning and measures for reducing methane.

Definition of Accident and Rational Analysis on Its Occurrence Cause (10) - The definition of accident holds a major position in accident prevention, safety management and legislation. In this paper, the authors gave the definition of accident, analyzed the occurrence cause of the accident and put forward the basic principle of accident prevention from the angle of the system and its operation, which can play a positive role in the guidance of the accident management and prevention.

Development of KJ90 Following Location and Attendance Management System for Underground Personnel (13) - This paper briefly analyses the demand prospects of underground personnel following location and attendance management system in coal mines and emphatically describes KJ90 following location and attendance management system for underground personnel according to its working principle, constitution, structure and technological features, which provides some references for the readers to understand the technological performance of this product.

Application Research on Hydraulic Loosening by Shallow Holes for Controlling Gas Disaster in Coal Faces (15) - This paper summarized the tests of applying hydraulic loosening by shallow holes for controlling gas disaster in coal faces in Baijiao Mine, Furong Coal Mining Administration, and described the test zone, test schemes and results, its application, effectiveness analysis as well as the matters for attention in its application. The test results showed that this method has clear outburst - prevention effect, is simple for operation, flexible, reliable, and easy to be accepted, and has better spread and application prospects.

Applying Economic Means to Intensify Environmental Management (18) - This paper gives an analysis on the environmental problems in the course of the conversion of economic system in our country and makes a discussion on the methods and measures for the solution of the environmental problems presented in the economic growth by economic means under the condition of socialist market economy. The authors, on the basis of the present environmental pollution, pointed out that it is necessary to intensify environmental protection and management by various economic means so as to promote the establishment and effective implementation of coordinated development and virtuous circulating mechanism of environment and economy.

Environmental Issues Faced with by Coal - based Energy Consumption Structure and Its Countermeasures (21) - This paper gives an analysis on the environmental problems caused by coal - based energy consumption in our country, and proves the necessity, feasibility and measures of the change of coal - based energy consumption from the angle of protecting ecological environment and promoting the coordinated development of social economy, energy and environment.

Distribution Pattern of Ground Temperature in Liuzhuang Mine Field and Analysis on its Inducing Factors (26) - Marked geothermic abnormity exists in Liuzhuang Mine Field and it has become an important factor affecting coal mining, so attention should be paid to it. This paper made study of and summarized the geothermic status and its distribution pattern in Liuzhuang Mine Field, and analyzed the geological factors that may induce geothermic abnormity, all of these can provide reference basis for the application of rational cooling measures in mine development and construction.

Application of Fuzzy Comprehensive Judgement Method in Evaluation of Underground Water Quality in Mining Area (36) - In order to make more rational appraisal for the underground water quality in a coal mining area, the authors conducted practical appraisal for the underground water quality in a mining area with fuzzy comprehensive judgement method by using phenol, cyanogen, etc. as the appraisal factors and appropriately choosing the weight values of the appraisal factors from subjective and objective respects, and put forward several proposals for prevention and control of continuous deterioration of underground water quality.

Practice and Development of Gel Fire Prevention and Control Technique in Yangquan Coal Mining Area (39) - Methane content is high and spontaneous combustion occurred frequently in Yangquan coal mines, which have a serious influence upon the safe production in the mines. For this reason, various kinds of gel fire prevention and control techniques have been used for the effective fire - fighting and control of different fires happened in roadways, working faces and gobs. The practice showed that the gel fire prevention and control technique is an efficient, economic and safe fire - fighting means suitable for high - gassy mines.