MDAG.com Internet Case Study 83

PAG, PAF, NAG (Non-PAG), and NAF - the Acronyms

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1. Introduction

How do acronyms affect our understanding of technical issues?

A Google AI response is:

> "Acronyms can both aid and hinder understanding, depending on context and audience familiarity. While they can condense information and simplify language, their misuse or misinterpretation can lead to confusion and hinder effective communication...."

Potential benefits include:
- condensation/efficiency, where acronyms can shorten lengthy technical terms or phrases, making communication quicker and more efficient; and
- group identity where acronyms can create a sense of belonging and shared knowledge within a specific group or field.

Potential drawbacks include:
- misinterpretation,
- confusion, and
- alienation.

Note the interplay between benefits and drawbacks. For example, if an acronym is shown to be misunderstood or misinterpreted, defensive responses can arise from the group feeling challenged, as illustrated in Section 2 below.

In the fields of minesite drainage chemistry, environmental geochemistry, and metal leaching and acid rock drainage (ML-ARD), a major document is the 600-page "ML-ARD Prediction Manual" (Price, 2009) which contains industry standard practices and best practices[1].

Here are some relevant quotations from this ML-ARD Prediction Manual.

> "Part of the reason for the large number of definitions [and acronyms] ascribed to the terms used in drainage chemistry prediction has been the lack of clarity regarding many of the key concepts. More accurate and precise terminology requires distinction between: different phenomena (e.g. *the distinction between acid generation and net acidic drainage* [emphasis added here])..."

[1] MDAG disclosure of bias: the Preface of this Prediction Manual states "Major technical assistance was provided by Kevin Morin (Mine Drainage Assessment Group)... and Kevin Morin provided major editorial assistance."

"A disadvantage of increased precision in terminology is the proliferation of cumbersome prefixes and acronyms."

"Accurate, clearly defined terminology must be used to ensure that results are not misinterpreted... Presently, there is *little consistency in terminology even between practitioners within the same jurisdiction* [emphasis added here]."

2. What is Meant by PAG, PAF, NAG (Non-PAG), and NAF

2.1 The Typical, Incorrect Definitions of PAG, PAF, NAG, and NAF

For ML-ARD, the pair of acronyms most often used are PAG and NAG. In most cases, they are defined as:

PAG = Potentially Acid Generating
NAG = Non-Acid Generating

In some regions, the acronyms are somewhat different but with virtually the same definitions:

PAF = Potentially Acid Forming
NAF = Non Acid Forming

From scientific perspectives, these definitions are wrong.

In the context of ARD, "acid generating" includes the process of sulphide-mineral oxidation that releases sulphate, acidity, heat, and many elements. "Acid generating" can also include metal hydrolysis in water and dissolution of pre-existing acidic minerals (Price, 2009).

According to these scientifically valid explanations of acid generation, for any solid-phase geologic rock, soil, or sediment to be PAG, it simply has to contain some sulphide even if the level is below the human limitation of analytical detection limits. As a result, virtually all rock, soil, and sediment are PAG and PAF because none can be proven to contain absolutely zero sulphide.

Conversely but by the same argument, no geological materials can be proven NAG and NAF.

Therefore, scientifically and technically, the above definitions of PAG, PAF, NAG, and NAF are wrong for distinguishing geologic materials that could release ARD. Remarkably, many documents about ARD, even now, define PAG, PAF, NAG, and NAF in this incorrect manner. This shows (1) the authors are not sufficiently aware of the science of ML-ARD and (2) serious misinterpretations and errors may be present in the document. Furthermore, many ML-ARD studies stop when the authors consider PAG/PAF separable from NAG/NAF. The errors inherent in this simplistic approach are discussed below and in Section 3 of this MDAG Case Study.

In my 47 years of experience in ML-ARD, I have encountered the following problems with this incorrect usage of PAG, PAF, NAG, and NAF.

- ML-ARD professionals wrote and said that NAG materials were "benign" or "inert" or "non-reactive" with no scientific proof other than their classification as NAG/NAF. In one case, at a minesite regulated for concentrations of sulphate in its effluents, its NAG/NAF rock was said to be inert simply because it was classified as NAG/NAF and could thus be placed close to a river. The minesite placed it next to a river. The internal sulphide oxidation in the NAG/NAF waste rock released sulphate to the river and exceeded allowable levels, triggering expensive reactive mitigation.

- As another example, non-technical audiences were told that NAG/NAF materials were benign based on no testing or insufficient data and that NAG/NAF could be used on site for roads, cover, remediation, etc. This led to significant degradation of water quality.

- Elsewhere, when their incorrect usage of NAG/NAF was pointed out to ARD experts, they basically responded "everyone knows what we actually mean". Yet they do not, not even these experts, because they cannot define the acronyms in a scientifically defensible way. A related response in other cases was basically "everyone else uses the acronyms this way". Section 1 above explains why these attitudes, reflecting group identity, are unacceptable.

PAG/PAF is typically distinguished from NAG/NAF using Acid Potential (AP) and Neutralization Potential (NP). Mathematically, Net Potential Ratio (NPR) is NP/AP and Net Neutralization Potential (NNP) is NP - AP. Notably, NPR and NNP are complex in their own right with PAG/PAF frequently being underestimated (e.g., MDAG Case Studies: Morin, 2021, 2019, 2018, 2014, 2007, 2006, 1999, and Morin and Hutt, 1997 and 2001). Additionally, NPR and NNP can even be relatively unimportant on the full scale (Morin, 2017) and where "Most of the contaminants may be produced by only a small portion of total material, drainage or during certain times of the year." (Price, 2009)

In any case, NPR and NNP values at a site usually display ranges, with some less than a site-specific criterion (PAG/PAF) and some above a criterion (NAG/NAF). Because NPR and NNP are typically continuums around a criterion, it makes no sense to think of PAG/PAF as reactive and NAG/NAF as non-reactive. This is not like "turning on and off a light". Significant amounts of NAG/NAF materials can badly contaminate water, as explained in Section 3 below.

2.2 Alternative and Scientifically Defensible Definitions

In 2009, ML-ARD Prediction Manual (Price, 2009), mentioned in Section 1 above, pointed to the major problem in defining PAG, PAF, NAG, and NAF as discussed in Section 2.1 above: "the distinction between acid generation and net acidic drainage".

Based on scientifically and technically defensible bases, the ML-ARD Prediction Manual (1) altered one acronym, from NAG to non-PAG and (2) used the net effect of NP/AP as acid rock drainage (ARD) rather than acid generation (Price, 2009):

"Material categories for future drainage pH are potentially acidic drainage generating (PAG) and not potentially acidic drainage generating (Non-PAG)."

As a result, the ML-ARD Prediction Manual (Price, 2009) provided the following, technically correct definitions:

PAG = "potentially acid rock drainage [ARD] generating" and "net acidic"

"Potentially acidic drainage generating (PAG) material is presently net neutral or alkaline material that is either predicted to become net acidic in the future or material whose future net drainage pH is uncertain."

Non-PAG = "not potentially acid rock drainage [ARD] generating" and "net neutral"

Non-PAG should not be assumed as benign or inert. "Although impacts from sulphide oxidation and dissolution most commonly result from acidic drainage and metal leaching, environmental impacts may also occur from drainage with a near neutral or basic pH. It is important to note that constituents of non-sulphide minerals may also be a drainage

chemistry concern."
"Drainage chemistry prediction should be conducted even for Non-PAG material because environmental impacts can also occur due to near-neutral and alkaline pH drainage."

3. Non-PAG Geologic Materials Can Also Degrade Water Quality with Near-Neutral Treatment Costs Sometimes Exceeding ARD Treatment Costs

As explained in Chapter 2 above, the acronyms of PAG, PAF, NAG, and NAF are typically defined incorrectly and misunderstood by many, despite the critical importance of correct definitions as explained above in Section 1. To correct this, the ML-ARD Prediction Manual (Price, 2009) provided scientifically defensible definitions and changed "NAG" to "non-PAG".

A major bias in ML-ARD studies, even today, is the assumption that non-PAG geologic materials are automatically environmentally benign unlike PAG materials. They are not - they can be worse.

Sufficient treatment of relatively "trace" levels of contaminants in near-neutral water can be more difficult and more expensive that sufficient treatment of ARD. This is partly due to ARD treatment beneficially creating relatively large amounts of precipitants scavenging contaminants from the water.

In Canada, an example for treatment and remediation of near-neutral drainage with elevated selenium and nitrate will cost billions of Canadian dollars[2]. Also in Canada, at similar annual flow rates, annual treatment of near neutral water with nitrate and elements like cobalt or molybdenum cost about twice as much as annual treatment of severe ARD.

Despite this common knowledge, many ML-ARD studies basically stop when the authors consider PAG/PAF separable from NAG/NAF. The implication is "bad" PAG can now be sorted from "good" Non-PAG and the necessary work is done, but this is typically wrong. In some cases, the authors seem aware that a near-neutral ML study is warranted, but they apparently do not know how to proceed since different predictive approaches and testwork are needed than for an ARD study.

Based on simplistic diagrams (Figures 3-1 to 3-3), most ML-ARD studies assume that no non-PAG materials will release significantly contaminated water (Figure 3-1). This is the extreme best-case scenario that likely does not happen often since ML-ARD does not simply "turn on" for PAG material and "turn off" for non-PAG material. This common assumption is unlikely in many cases, although it can be proven in advance with proper testwork (Price, 2009).

Instead, a significant portion of, or in the extreme all, non-PAG material can also release ML-ARD and adversely degrade water quality (Figures 3-2 and 3-3). As a result, many past and current ML-ARD studies underestimate the severity and extent of ML-ARD and underestimate the volumes of reactive geological material that can degrade water quality.

Based on the preceding discussion, an equation that applies to many ML-ARD studies is:

Geologic materials that can significantly degrade water quality=

PAG materials +

Underestimated PAG materials due to common overestimation of NPR +

Some portion of Non-PAG materials

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[2] https://www.cbc.ca/news/canada/british-columbia/selenium-teck-coal-mine-toxic-pollution-1.7149181

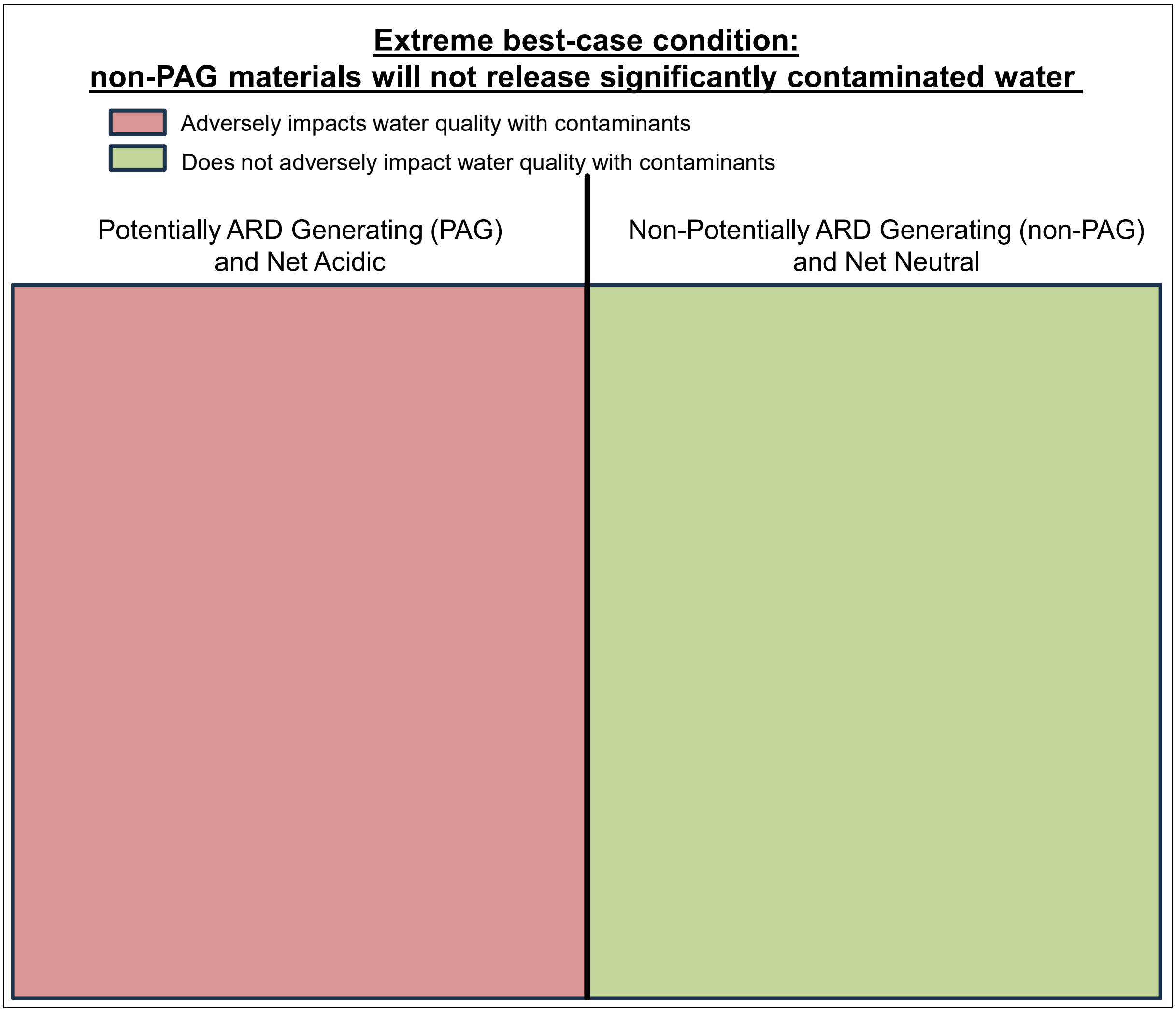

Figure 3-1. Simplistic schematic diagram of the extreme best-case condition where only PAG geologic materials adversely affect water quality.

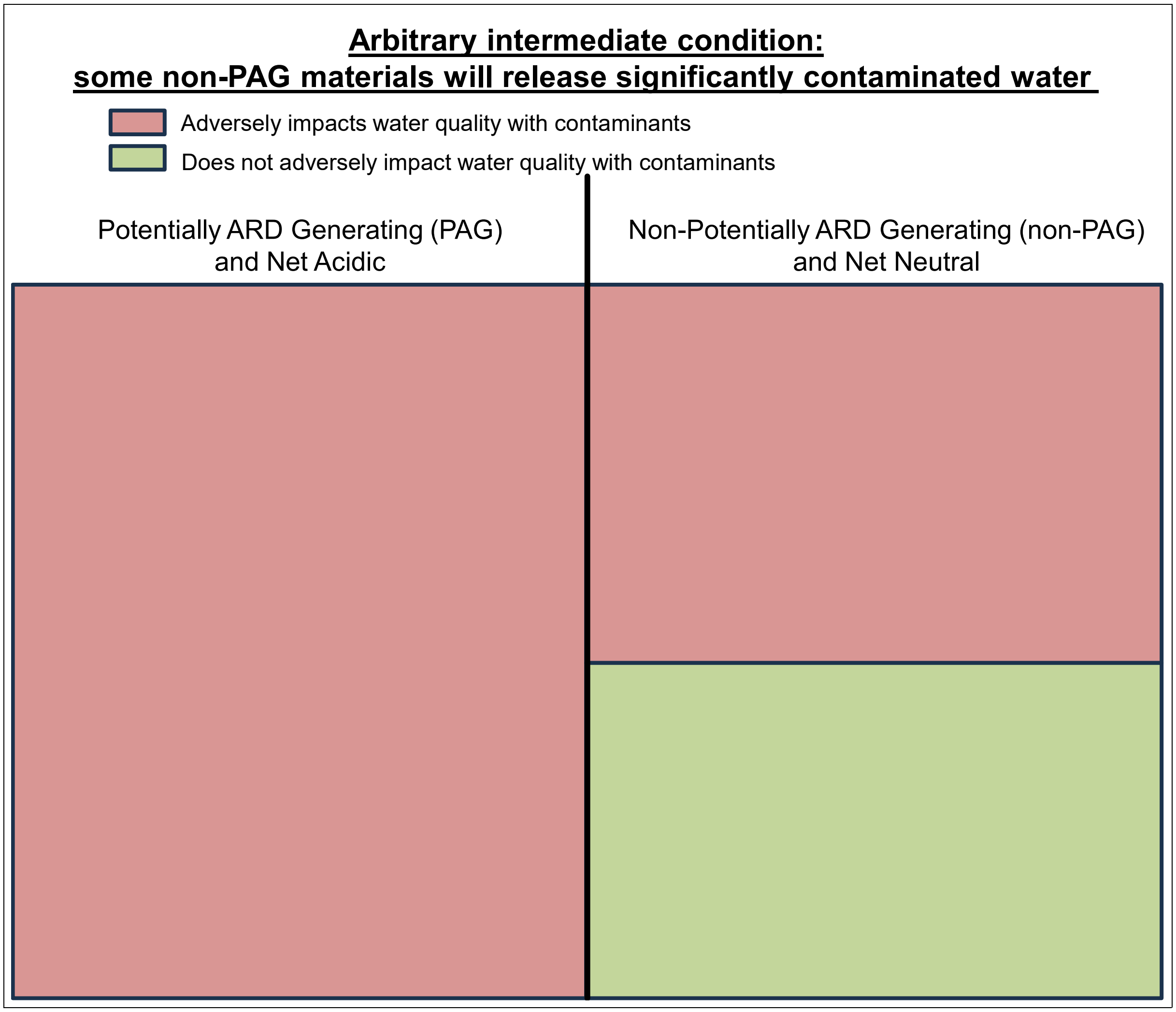

Figure 3-2. Simplistic schematic diagram of an arbitrary intermediate condition where all PAG and some Non-PAG geologic materials adversely affect water quality.

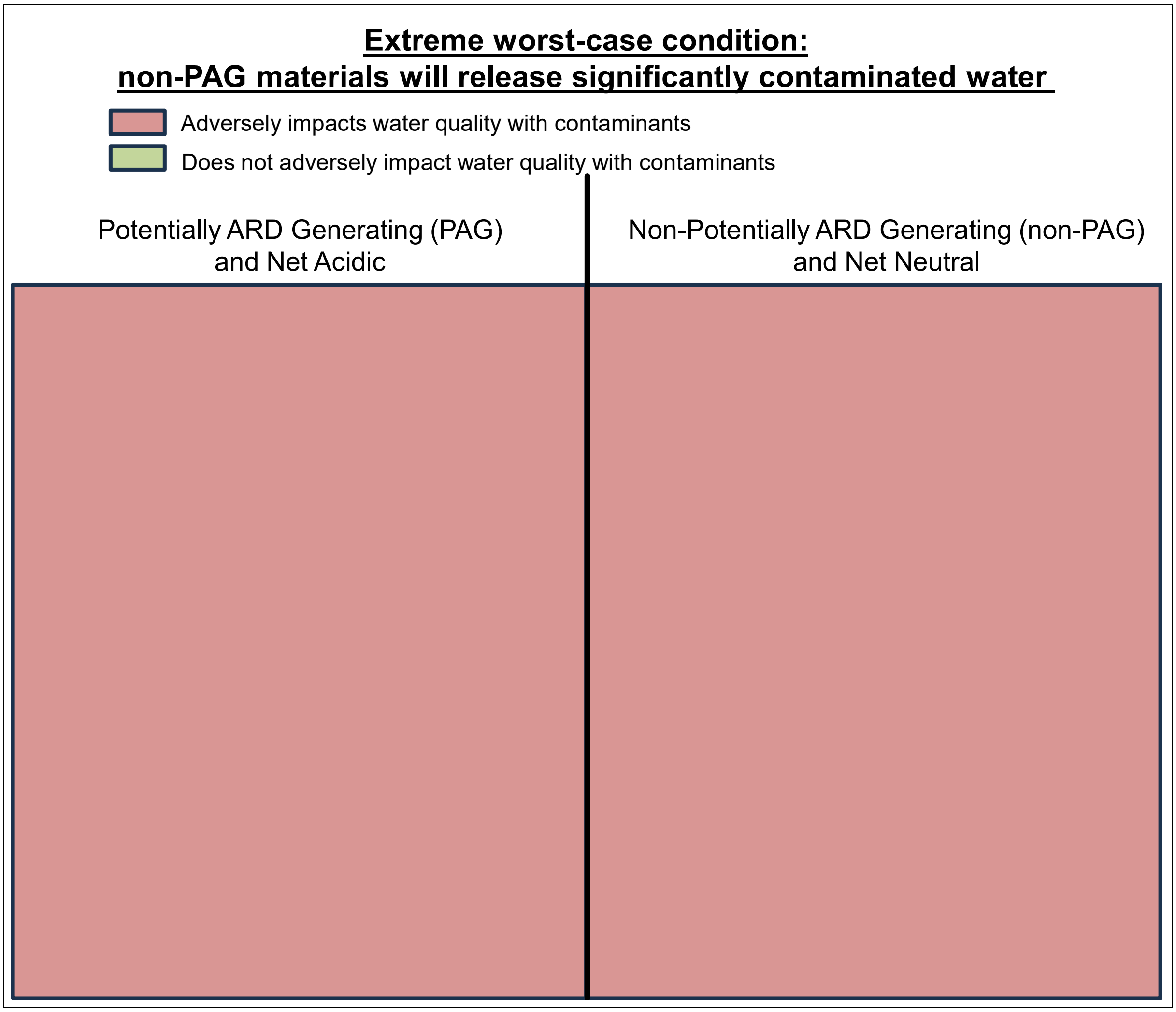

Figure 3-3. Simplistic schematic diagram of the extreme worst-case condition where both PAG and Non-PAG geologic materials adversely affect water quality.

4. References

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