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Abstract

The authors performed a citation analysis of 15 source papers that were written in the field of corrosion chemistry. Each of the source papers were written on the specific topic of the corrosion of mild steel. The researchers were from a variety of different countries, including China, Egypt, Germany, India, Lesotho, Nigeria, Saudi Arabia, South Africa, Spain, Turkey, and the United States. The authors found that articles that had one or more researchers from an African country cited works that had versions in the Open Access (OA) domain twice as often (12.2%) when compared to articles that did not have an author from Africa (5.5%). The authors also evaluated the types of Open Access resources that the researchers cited, and the error rates found within their citations.

Introduction

There are many articles and reports that note the information needs of scholars in Africa. The issues are many-layered and complicated. Some of the issues concern: the institutional cost of subscribing to scientific journals (Nwagwu and Ahmed (2009), Suber and Arunachalam, 2006); the electrical and telecommunications infrastructure including computers and the quality and speed of the Internet access (Krubu and Osawaru (2011); Issa, et al. 2011); and the skills and ability of library staff to take advantage of the available resources (Lor and Britz, 2010). It is also known that situations are different depending upon geographic location within Africa. Researchers in some African countries may have an easier time finding and using scholarly resources than those who live in less developed parts of Africa. (Gyamfi, 2005).

Because some researchers in Africa may have a hard time accessing the scientific scholarly literature from subscription journals, the authors wanted to determine how much Open Access literature was used and cited in the field of corrosion chemistry. It was assumed that if an article was cited, then it must have been read and used at some point.

Overview of Open Access

There are several definitions of Open Access. It is the "free and immediate online access to peer-reviewed journal literature" (Crow, 2009, p. 2). In 2001, the Open Letter to Scientific Publishers signed by tens of thousands of scholars worldwide called for "…the establishment of an online public library that would provide the full contents of the published record of research and scholarly discourse in medicine and the life sciences in a freely accessible, fully searchable, interlinked form." (Public Library of Science (PLoS)). Dr. Peter Suber, Senior Researcher at the Scholarly Publishing & Academic Resources Coalition (SPARC), and historian and researcher of the OA Movement, refers to these documents collectively as the BBB definition. This includes statements made about OA from the Budapest Open Access Initiative (BOAI, 2002), the Bethesda Statement on Open Access Publishing (Suber, 2003), and the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities (Berlin Declaration, 2003).

Suber (2007) defined OA literature as digital, online, free of charge, and free of most copyright and licensing restrictions. OA publishing is compatible with copyright, peer review, revenue (commercial for-profit), print, preservation, prestige, career-advancement, indexing services, and other features and supportive services associated with conventional scholarly literature.

There are two primary locations where researchers will find OA articles. (Suber, 2004) Open Access articles can be found in subject archives or institutional repositories, and this is called green OA. Open Access journals also provide readers with free direct access to articles from the publisher; this is called gold OA.

Use of Scientific Resources by Chemists and Engineers

It is known that scientists and engineers employ a variety of methods to find and read full texts of articles. Scientists and engineers may or may not rely on library subscriptions or personal journal subscriptions for their information needs. Researchers in engineering often use a network of colleagues for sources of information. (Tenopir and King, page 59 and 83) Chemists and scientists in general tend to read more journal articles as compared to engineers. (Tenopir and King, page 157)

Since Alma Swan and Sheridan Brown (2005) had found that chemists are reluctant to post article preprints or postprints to institutional or subject based repositories, the authors were not sure

how many green OA articles would be found in the references of the 15 source articles. Swan and Brown also noted that "there have been instances of publishers refusing an article submitted by an author who has self-archived the preprint on the grounds of prior publication." The rejection rate was higher in chemistry, so chemists may be discouraged from posting their articles in subject or institutional repositories.

Use of Freely Available Scientific Resources in Africa

Dulle, Minish-Majanja, and Cloete (2010) found adoption rates of OA for scholarly communication in Tanzanian public universities. Their research demonstrated that more of the researchers simply accessed free online content (62%). This was three times more than those who also disseminated their scholarship through OA (20%). While the majority of researchers expressed an enthusiastic willingness to disseminate their content through OA outlets, some were not able to take advantage of those opportunities.

Bowdoin found that 2.8% of the use of DOAJ was from researchers in Africa, even though 15% of the world's population is in Africa. (Bowdoin, 2011) Limited access to computers and the Internet could be the main reason why they do not access the DOAJ much more.

Henneken, Kurtz, and Accomazzi (2011) noted that there is "a rapid increase in Internet user density" from users in Africa (not including South Africa) who use the SAO/NASA Astrophysics Data System (ADS). While this is not a database of Open Access articles, they demonstrate that researchers in Africa are increasing their use of this freely available scientific database.

At the 2012 SPARC Open Access Meeting, Stuart Shieber (2012) showed that many researchers from countries in Africa use the Digital Access to Scholarship at Harvard (DASH) repository.

Research Questions

Some of the background evidence indicates that researchers in Africa use the Open Access literature because they may not have access to as many subscription journals. But, it is also known that chemists are hesitant to publish their papers in green OA repositories. With this background evidence, the authors wanted to get a sense of the amount and types of OA literature the corrosion chemists are citing, since that is an indication of information use.

The authors know that some countries in Africa have information access issues, they wanted to see if the African researchers were taking more advantage of OA journal articles when compared to researchers who are based in other countries. If they cite OA articles, what types of OA resources do they cite? Since the authors know that researchers and journal editors are not perfect, they expected to see some errors in the citation lists. The authors wanted to see if the sources that were from commercial journals would have less typos and error rates than the references from OA sources. Would the commercial journals provide cleaner references?

Methodology

The authors identified a sample of 15 recent articles from a variety of scholars and from a range of countries. In order to keep a narrow focus, the topic of the source articles concerned the corrosion chemistry of mild steel. The source articles were published from 2008-2011. Table 1 lists the papers that were identified.

Article Number	Title of source article	Type of Article	year of publication
1	Corrosion Inhibition and Adsorption Properties of Ethanol Extract of Vernonia Amygdalina for the Corrosion of Mild Steel in H2SO4	OA	2009
2	Quantum chemical study of the inhibition of the corrosion of mild steel in H2SO4 by some antibiotics.	Commercial, Springer	2009
3	The effect of some triazole derivatives as inhibitors for the corrosion of mild steel in 1 M hydrochloric acid	Commercial, Elsevier	2009
4	Effect of sodium chloride on corrosion of mild steel in CO2-saturated brines	Commercial, Springer	2011
5	Quantum chemical studies on the corrosion inhibition of some sulphonamides on mild steel in acidic medium	Commercial, Elsevier	2009
6	Inhibition of the corrosion of mild steel in H2SO4 by penicillin G	OA	2009
7	QSAR of lauric hydrazide and its salts as corrosion inhibitors by using the quantum chemical and topological descriptors	Commercial, Elsevier	2011
8	Synergistic inhibition behaviour of methylbenzyl quaternary imidazoline derivative and iodide ions on mild steel in H2SO4 solutions	Commercial, Elsevier	2009
9	Long-term atmospheric corrosion of mild steel	Commercial, Elsevier	2011
10	Electrochemical characterisation of the ability of dicarboxylic acid salts to the corrosion inhibition of mild steel in aqueous solutions	Commercial, Elsevier	2011
11	Adsorption properties and inhibition of mild steel corrosion in sulphuric acid solution by ketoconazole: Experimental and theoretical investigation	Commercial, Elsevier	2010
12	Evaluation of the inhibitive effect of some plant extracts on the acid corrosion of mild steel	Commercial, Elsevier	2008
13	Streptomycin: A commercially available drug as corrosion inhibitor for mild steel in hydrochloric acid solution	Commercial, Elsevier	2009
14	Joint effect of halides and ethanol extract of Lasianthera africana on inhibition of corrosion of mild steel in H2SO4	Commercial, Springer	2009
15	Mebendazole: New and efficient corrosion inhibitor for mild steel in acid medium	Commercial, Elsevier	2010

Table 1.

At the end of an identified article, the authors searched the citation list using Google Scholar to see if there were any freely available versions of an article. If it wasn't available in Google Scholar, then the table of contents of the cited journal was browsed. Some green OA articles may have been missed since Google Scholar doesn't index everything. If a cited reference was not findable in Google Scholar nor through browsing the table of contents of the journal, then it was determined that it would be very difficult for a researcher to find a green or gold OA version of an article. Those references were marked as not having an OA version available.

In some of the source articles, the full title of the cited articles were provided in the references, so it was relatively easy to cut and paste the title of the referenced article into Google Scholar. However, most of the articles had a small number of errors or typos in the references. For example, there were errors for author names, words in the title of the article were misspelled, journal titles or abbreviations were incorrect, and volumes, years or page numbers were incorrect. Even though some article titles in the references had typos, the true article title was found after noting the errors. Google Scholar was searched with the correct referenced article title. Several pieces of information were noted next to the references.

1. If the cited item was available in a gold OA journal
2. If the cited item was available in a green OA source and the base URL of the location
3. The publisher of the cited item

Some cited references were more difficult to locate. Some of the source articles did not have references that included the title of the article. In those situations, four methods were employed to determine the title of the referenced article.

1. Search Google Scholar using the author names, title of the journal, the year of publication and the page number.
2. For the articles that were published by Elsevier, we would often find full journal titles through the "View Record in Scopus" links.
3. Browse the table of contents of the journal issue to find the title of the article.
4. Find another article that cited the same item, and that other article would cite the title of the item.

This is an example of the process the authors used to determine the titles of the referenced articles. Figure 1 below shows the first four references from source article number 12, "Evaluation of the inhibitive effect of some plant extracts on the acid corrosion of mild steel."


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Adsorpt. Sci. Technol., 18 (2000), p. 177

View Record in Scopus | Full Text via CrossRef | Cited By in Scopus (20)

[2] M. Kissi, M. Bouklah, B. Hammouti, M. Benkaddour
Appl. Surf. Sci., 252 (2006), p. 4190

Article | PDF (322 K) | View Record in Scopus | Cited By in Scopus (43)

[3] E.E. Oguzie, G.N. Onuoha, A.I. Onuchukwu
Mater. Chem. Phys., 89 (2004), p. 305

[4] E.E. Oguzie
Mater. Lett., 59 (2005), p. 1076

Article | PDF (90 K) | View Record in Scopus | Cited By in Scopus (36)

Figure 1.

Several source articles were published in the Elsevier ScienceDirect system. In order to determine the title of the referenced article, the record was opened with "View Record in Scopus." The article title was cut and pasted from the Scopus preview, then Google Scholar was used to determine if there were any OA versions of an article available. In a small number of cases, the table of contents of a journal was browsed to find gold OA articles, since they were not findable in Google Scholar.

After using this procedure, the authors found that the article title of reference [1] from Figure 1 by Ameer, Khamis and Al-Senani is "Adsorption studies of the effect of thiosemicarbazides on the corrosion of steel in phosphoric acid." In this case, there was no freely available version of the article according to Google Scholar. See Figure 2.

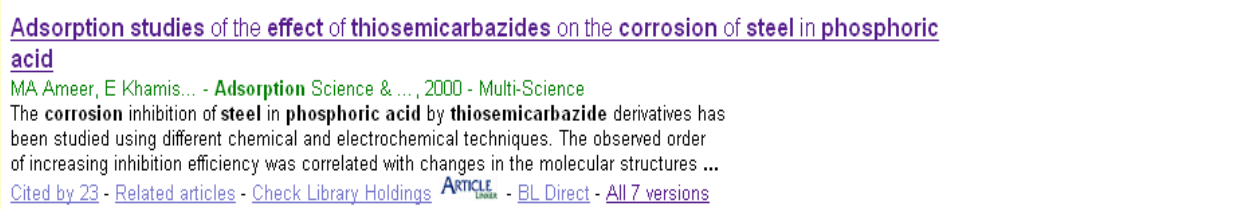

Figure 2.

Another reference from the same article (Reference [25]) showed that it was available from a source outside of the publisher. See Figure 3. The authors opened up the PDF version to make sure that it was available from that source.

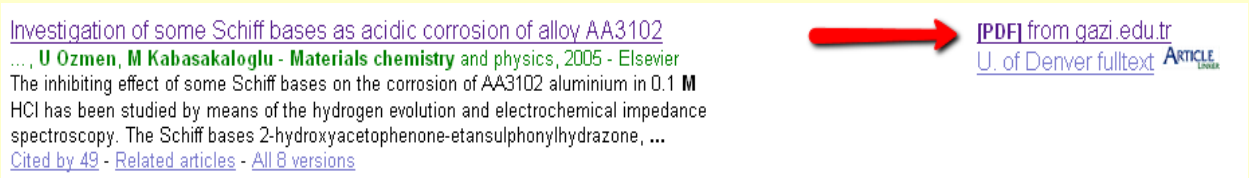

Figure 3.

Some of the references had typos or were poorly constructed, so it was difficult to identify the intended article. Some of the error we encountered were:

- Author names were misspelled
- Authors were missing
- Referenced article titles had typos
- Journal titles or their abbreviations were incorrect or were misspelled
- Page numbers were incorrect
- Volume numbers were incorrect

In the case of Reference [3] in Figure 1 by E. E. Oguzie, there is no link to "View Record in Scopus." In this case, we browsed the table of contents of volume 89 of the journal to find the article that started on page 305. There was no link to the Scopus Record because the reference was actually published in 2005 instead of 2004.

In the references of source paper number 14, "Joint effect of halides and ethanol extract of Lasianthera africana on inhibition of corrosion of mild steel in H2SO4," there are two references to *J Phys Chem*. See Figure 4 below. However, reference 19 is actually to an article in *Physical*

Chemistry: An Indian Journal (http://www.tsijournals.com/pcaij/), while Reference 21 is to the American Chemical Society publication, *Journal of Physical Chemistry*.

19. El Ashry HE, El Nemr A, Esawy SA, Ragab S (2006) J Phys Chem 1:41
20. El Ashry HE, El Nemr A, Esawy SA, Ragab S (2006) Electrochem Acta 51:3957
21. Gomez B, Likhanova NV, Dominguez-Aguilar MA, Martinex-Palou R, Vela A, Gazquez JL (2006) J Phys Chem 110:8928

Figure 4.

After some digging, the authors were able to determine all of the references through a process of trial and error.

Results

In Table 2, the number of article references is less than the total number of references. Because scientific scholarly conference papers are important to researchers and they are often found in OA repositories, they were also considered to be "articles" of information. In addition to journal articles and conference papers, the researchers also occasionally cited books, book chapters, software, standards, and other gray literature, and those items were not marked as article references.

The source articles that were written or co-written by researchers from Africa had citations where 12.2% of articles and papers that were available as Open Access. See Table 3. The six source articles that were written by authors who were not based in Africa cited 217 articles with only 12 references from OA sources, thus 5.5% of their references were in the Open Access domain. It appears that corrosion chemistry researchers in Africa cite double the Open Access literature than those who live outside of Africa.

The authors also found that of the 58 OA article citations, 34 references (59%) were Gold OA, and 24 references (41%) were Green OA. The average OA citation rate for all of the source articles was 9.78%. See Table 2.

Article Number	What countries are the authors from?	Total Number of References	Article References	Total Number of OA	Green OA	Gold OA	Percent of OA articles
1	Nigeria	30	26	4	0	4	15.38%
2	Nigeria, Egypt and South Africa	27	27	4	0	4	14.81%
3	China	37	36	0	0	0	0.00%
4	USA	30	28	6	5	1	21.43%
5	Turkey and Lesotho	56	50	5	2	3	10.00%
6	Nigeria	46	46	6	2	4	13.04%
7	Egypt and Saudi Arabia	41	38	6	5	1	15.79%
8	China and Nigeria	68	67	4	2	2	5.97%
9	Spain	70	49	1	0	1	2.04%
10	Germany	32	30	2	2	0	6.67%
11	Nigeria	58	58	9	1	8	15.52%
12	Nigeria	32	32	3	1	2	9.38%
13	India	23	22	0	0	0	0.00%
14	Nigeria	35	32	5	1	4	15.63%
15	India	56	52	3	3	0	5.77%
Total OA citations for all 15 papers		**641**	**593**	**58**	**24**	**34**	**9.78%**

Table 2. OA citations from all 15 source articles.

Article Number	Where countries are the authors from?	Number of Article References	Total number of OA	Green OA	Gold OA	Percent
1	Nigeria	26	4	0	4	15.38%
2	Nigeria, Egypt and South Africa	27	4	0	4	14.81%
5	Turkey and Lesotho	50	5	2	3	10.00%
6	Nigeria	46	6	2	4	13.04%
7	Egypt and Suadi Arabia	38	6	5	1	15.79%
8	China and Nigeria	67	4	2	2	5.97%
11	Nigeria	58	9	1	8	15.52%
12	Nigeria	32	3	1	2	9.38%
14	Nigeria	32	5	1	4	15.63%
Total		**376**	**46**	**14**	**32**	**12.23%**

Table 3. OA citations for the source articles with authors from Africa.

The publisher of cited articles was tracked. It was found that 266 references out of 593 (44.9%) article and paper citations were to Elsevier journals. The rest of the citations were scattered to other publishers such as Springer, Wiley, AIP, the American Chemical Society and many others. In this narrow field of research, Elsevier publications are very important. However, only 9 of the 266 references were freely available outside of the Elsevier ScienceDirect server. Only 6 of those 9 references were posted by the authors on a locally controlled server, and none of those were to author submitted manuscripts. We did not find any references to articles where the authors paid for a "sponsored article." So, even though Elsevier is Green OA compliant according to SHERPA/RoMEO (http://www.sherpa.ac.uk/romeo/search.php?id=30), it did not appear that the researchers were taking advantage of the opportunity to post manuscripts of their articles.

Some researchers claim that OA journals have less quality editing than traditional publishing outlets. There is a "perception that open-access journals are of lower quality than traditional publications." (Fischman, 2011) While only two of the fifteen source papers were published in gold Open Access journals, it was found that there were several errors and typos in the references from the commercial journal articles as well as in the references from the two gold OA sources. See Table 4. Thirteen of the fifteen articles had one or more errors in the references. Just because an article is published in a commercial journal does not mean that it is free of errors. Article number 14, which was published in a commercial journal, had a higher error rate per reference than article number 6 which was published in an Open Access Journal.

Article Number	Type of publication	Total Number of References	Errors	Errors per Reference
1	OA	30	2	0.067
2	Commercial	27	2	0.074
3	Commercial	37	1	0.027
4	Commercial	30	1	0.033
5	Commercial	56	4	0.071
6	OA	46	8	0.174
7	Commercial	41	2	0.049
8	Commercial	68	0	0.000
9	Commercial	70	1	0.014
10	Commercial	32	1	0.031
11	Commercial	58	6	0.103
12	Commercial	32	1	0.031
13	Commercial	23	0	0.000
14	Commercial	35	8	0.229
15	Commercial	56	4	0.071

Table 4.

How Do Researchers Get Papers to Read and Cite?

There are a number of methods that researchers employ to find and research the literature. It is known that some researchers may share and email copies of articles to colleagues at other Institutions. (Tenopir and King, page 73; Markusova) Researchers in some countries with low GDP per capita (such as Nigeria) had taken advantage of free access to Elsevier journals, but that situation may have recently changed. (Boseley, 2011)

It should be noted that the researchers may have used and cited the final published version of articles, and not the Green OA version of the articles even if they were available at the time of publication. The scholar may have received the final published version of an article through a library or other means.

It is possible that some referenced articles may have been OA at the time of citation, but they were not OA when the authors checked in March of 2012. Some referenced articles may have been OA as of March of 2012, but they were not OA when the researcher wrote the source article. For gold OA articles, it is most likely that they were OA during the time of citation from 2008 through 2011. For the green OA articles, it is possible that some articles appeared or disappeared between the time of citation and the time of this research.

Conclusion

In this very narrow field of research in corrosion chemistry, it appears that scholars in Africa do use and cite more Open Access resources. These researchers cited the OA literature at twice the rate (12.2% vs. 5.5%) of researchers from other parts of the world. The researchers cited more gold OA resources (59%) than green OA resources (41%). Within this small sphere of researchers, there seems to be much greater acceptance of the gold OA literature in Africa. It was found that 32 of the 34 gold OA citations were in the nine source papers with African authors. It is possible that the results and conclusions would be different if we had a larger sample size of source articles to evaluate, but analysis of the data would have taken considerably longer.

The authors wanted to compare the citation patterns of researchers in a narrow and focused subject area. If the source articles were expanded to include other areas of chemistry, then one could claim that the source papers came from too many subject areas. It could be said that organic chemists or atmospheric chemists use the literature completely differently from corrosion chemists. By determining the OA use of researchers in a single narrow subject area, that concern was avoided.

In the future, the authors may extend this research to include a wider variety of African authors and a different subject area. For example, it would be interesting to see how researchers from different areas of the world cite the literature of other subject areas. For example, If the research was performed in the area of physics, it might be found that researchers in Africa heavily used the physics e-print archive, www.arXiv.org.

The authors noticed that some of the source papers cited the same references, so it would be interested to see a co-citation analysis. This could be interesting future project.

Some of the source papers were written by authors from a variety of countries, so it might have been better if the source articles were limited to ones where only one country is represented. However, this restriction would have narrowed our pool of papers to sample from.

The authors also found that most of the articles had one or more errors in the reference lists. While we can't conclude that commercial journals have fewer errors than Open Access journal articles, we can state that some commercial journal articles may have as many errors as ones found in the Open Access Literature. The citation error rate may depend upon the author of the paper as well as the publisher of the article. Some OA publishers might provide cleaner references than others. For example, would PLoS articles have cleaner references than articles published by another OA publisher or commercial publishers? This may also be a good project for further investigation.

Overall, it was interesting to see that many of the corrosion chemists used OA resources. The authors will monitor the situation to see if the use of OA resources continues to grow for chemists in general and for corrosion chemists in particular.

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