Scientometric Analysis of Tribology Research in African Countries

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ABSTRACT

The aim of this paper is to examine the research productivity on tribology contributed by African countries. The related bibliographic records are extracted from Science Citation Index – Expanded of WOS. The analyzed parameters are: publication year, documenttype, language, country, institution, author, journal, number of citations andinternational collaboration. Earliest article in tribology research by African author was published in 1979. 80% of the total output was published between 2001 and 2014.Authors from Egypt, Tunisia and South Africa are engaged in tribology research more than other African countries. Future bibliometric analyses of articles published by African researchers will be focused to examine author and institutional level collaboration.

Keywords: Bibliometrics, Tribology, Africa

INTRODUCTION

Bibliometrics studies on the whole orpart of Africa are very limited as compared toothercontinents. In recent times, an evidentinterest has been registered e.g. Chuang et al (2011), Khan (2011), Ochallo (2012), Megnigbeto (2013), Dragos&Dragos (2014) andBreugelmans et al (2014). None has looked at tribology research as a whole in Africa.

Africa is a continent abundant in natural resources andabsolute volume of published papers is one indicator of research activity and indirectlyof research capacity (Adams, et al. 2014).Sub-SaharanAfrica only accounts for less than 1% of the world's research output, despite having 12% of the world's population. But thisstatistic hides the gains: between 2003 and 2012 the region more than doubled its yearly research output, raising its share of global researchfrom 0.44% to 0.72% over the period. Collaborations on Africa research output tend to be with institutions in the US and Europe, but a close look also shows that they follow colonialties.

Former British colonies will more likely work with the UK, as will France with Francophone African countries (http://mgafrica.com).

Most research in Africa focuses on agriculture and the health sciences, as the continent is battling serious diseases like HIV/AIDS, malaria, and most recently the Ebola epidemic. But missing from the equation is research in the physical sciences and in the science, technology, engineering and math (STEM) based fields(http://www.worldbank.org).One of the most positive signs for Africahas been the recent increase in scientificresearch being conducted by local Africanscientists. From 1996 to 2012, the numberof research papers published in scientificjournals with at least one African author morethan quadrupled (from about 12,500 to over52,000). During the same time the share ofthe world's articles with African authors almostdoubled from 1.2% to around 2.3% (Schemn 2013).In 1996, sub-Saharan researchers produced roughly 0.8% of the total papers in the Scopus database. By 2009, that fraction had reached about 1% (Irikefe, et al. 2011).

Research publications in peer- reviewed scholarly and technical journals are often seen asthe prime output of high-quality scientific knowledge production (Tijssen).The(increasing) domination of South Africa in the region is evidenced by the fact that itproduces more than 50% of all research output and three times more than the secondcountry (Nigeria whose output in ISI has been declining over the past twelve years); andfinally the continuing lack of visibility of much of this scholarship in international indexes (Mouton 2010).

The African Conference in Tribology, organized for the first time in Africa, was held at the NationalSchool of Applied Science of Marrakesh Morroco, April 2730,2014.The ACT will provide a platform to assemble researchers, practitioners, andacademics to present and discuss ideas, challenges and potential solutions onestablished or emerging topics relating to research and practice in Tribology(http://act2014.sciencesconf.org).Overall, if industry was able to get back to basics and focus on tribology, energy costs could bereduced by between 8 and 20%, and maintenance costs by 30 to 50%(Swan and Fitton 2010).

Boshoff (2009) examined collaboration ties in Central Africa's scientific output andfound that colonial and cultural ties play a major role in international collaboration.Mêgnigbêto (2013) compared scientific publications in West Africa and found that cooperation among the three countries (Benin, Senegal and Ghana) was negligible.

This study is designed to answer the following questions:

- Who are the main producers of African countries?
- How did research collaboration evolve in Africa?

- Who are the main research partners of African countries outside the continent?
- Which are the main African institutions (and authors) that are actively engaged in research?

METHODOLOGY

The data used in this study are drawn from Science Citation Index – Expanded of Web of Science. To retrieve the bibliographic records on tribology, the following Keywords were used in the combined fields of title, abstract, author keywords and keywords plus: *tribolog*, tribosyst*, tribo-syst*, tribo-chem*, tribochem*, tribotechn*, tribo-physi*, and tribophysi**(Elango et al., 2015). The search was conducted on Oct 2015 and limited to 2014. First all the records for the above keywords are extracted and then filtered the specific records of articles contributed by at least one African author.All the information relating to names of authors with affiliation information, title of article, year of publication, number of times cited, name of the journal are recorded and some manual coding was done.

RESULTS

In total 248 publications were contributed by African authors which includes Articles (222), Proceedings Papers (22), Reviews (3) and Letter (1). Almost all the publications werepublished in English (236; 96%) and few publications were published in French (8) and German (1). Among the 53 African countries, only 13 had publications in the field of tribology research during the study period. The year-wise output and their corresponding world share of African continent are shown in Figure 1. More than 80% of total output was published during the period 2001-2014, especially after 2007 there was publications in the double digit.

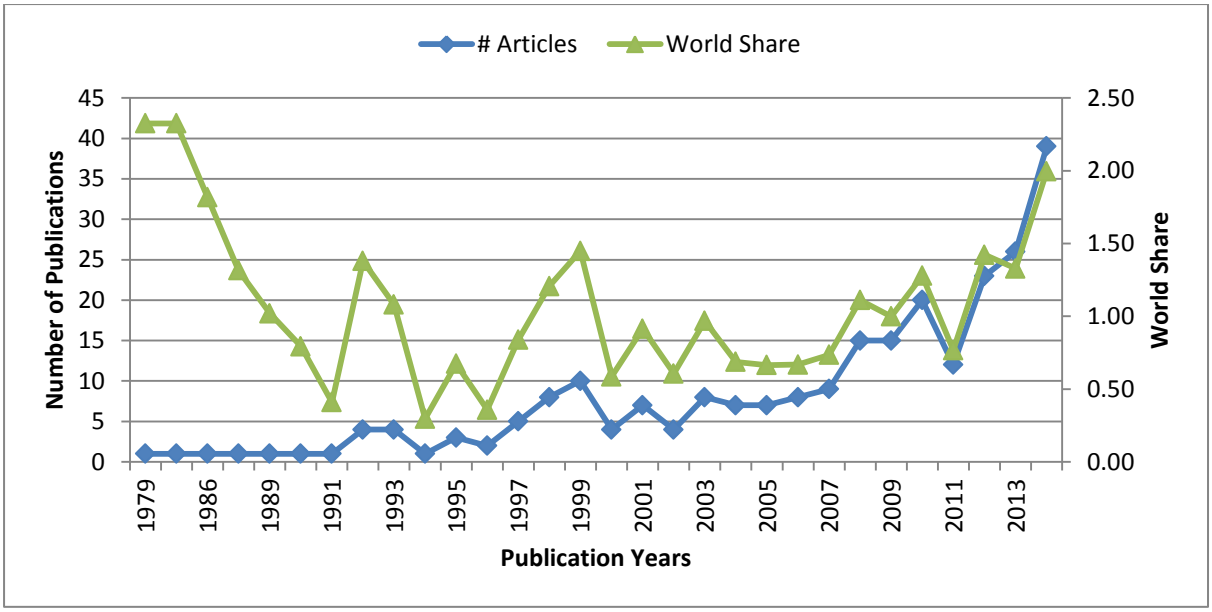

Figure 1 – Year-wise output and corresponding world share of African countries

General characteristics of tribology research output in Africa is presented table 1. The citation per paper is 6 with an h-index of 20. About 63% of total research output was published with international collaboration. Similar trend was observed in public health research with 58% (Chuang et al, 2011).

Table 1 - Scientometric overview of Tribology research in Africa

Period	1979-2014
# Articles	248
CPP	6
h-index	20
# Un-cited	53 (21%)
Avg. Authorship	3.55
ICP (%)	155 (63%)
Avg. References	24
Funded	51 (21%)
Avg. Pages	9

Of 53 African countries, only 13 countries were published in this research field (Table 2). Among the 13 African countries, Egypt tops the list with 89 publications followed by Tunisia (55), South Africa (38) and Algeria (37). Other African countries followed distantly. Similarly, Egypt was the top most prolific country among the African countries in the fields

of Chemistry, Engineering, Materials Science and Physics (Adams et al, 2010).This study also reveals that Egypt is more concentrating in pure sciences and engineering. Unlike other fields such as biomedical (Hofman et al, 2009) and public health (Chuang et al, 2011), Tunisia is the top second country in this research field.

Table 2 –African countries and their output

African country	# Articles	% of Total Articles
Egypt	89	35.89
Tunisia	55	21.77
South Africa	38	15.32
Algeria	37	14.92
Nigeria	14	5.65
Morocco	8	3.23
Uganda	4	1.61
Zimbabwe	2	0.81
Cameroon	2	0.81
Senegal	1	0.40
Namibia	1	0.40
Ghana	1	0.40
Cote Ivoire	1	0.40

Figure 2 shows the international co-authorship relations among the African countries. To visualize the collaboration network map of African countries, steps suggested by Elango, et al. (2013) are followed in Ucinet and Sci^2 software tools. Researchers from Egypt are not collaborated with other African countries and Tunisian scientists willing to collaborate with Algerian counterparts only.

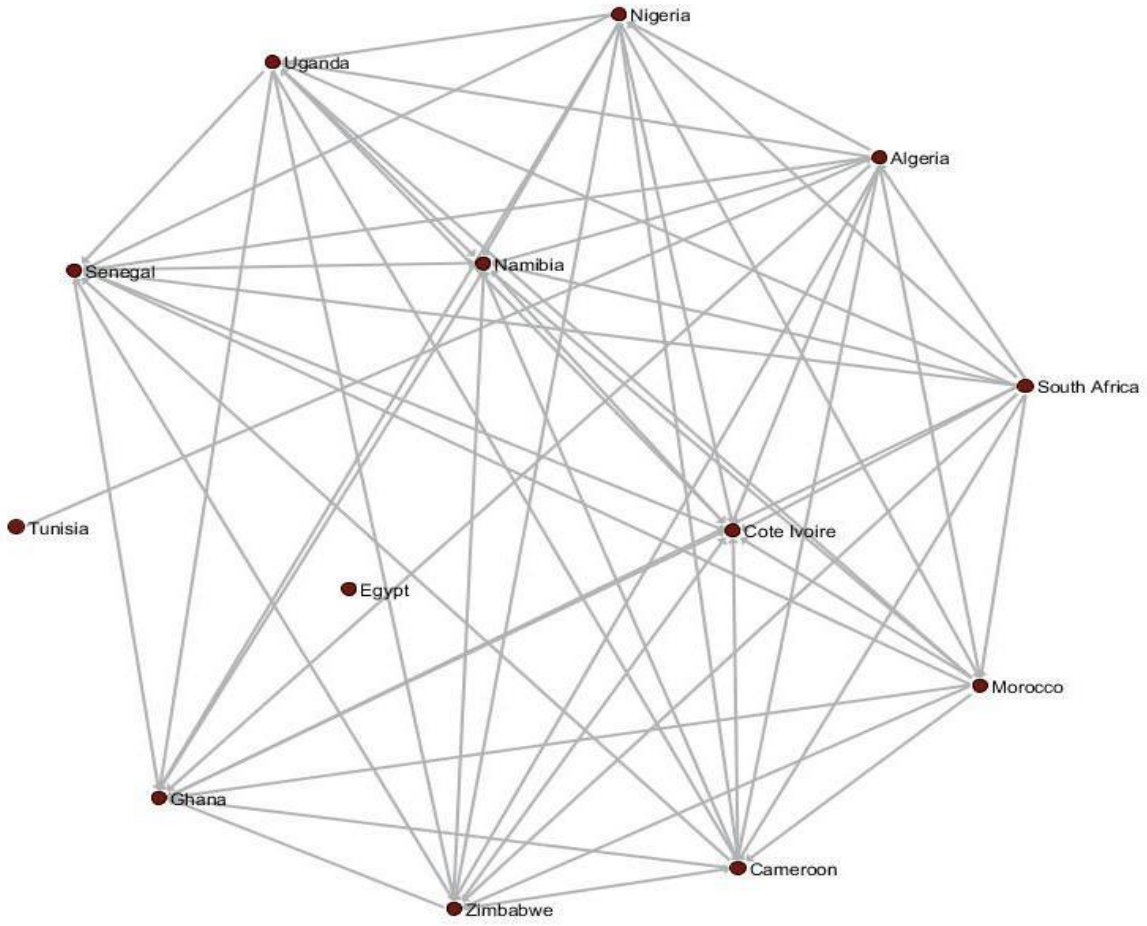

Figure 2 – Country level collaborations among the African countries

African researchers collaborated with researchers from 28 non-African countries. Frequently collaborated non-African countries are listed in Table 3. France topped the list with collaboration on 28% of articles, followed distantly by Malaysia(6%), Germany (5.34%), Saudi Arabia (4.03%), USA (3.23%) and Poland (3.23%). Of these 11 countries, 7 were European countries. The non-European countries were Malaysia, USA, Saudi Arabia and Iran.

Table 3 – Collaborating countries other than African continent

Country	# Articles	% of Total Articles
France	70	28.23
Malaysia	15	6.05
Germany	13	5.24
Saudi Arabia	10	4.03

USA	8	3.23
Poland	8	3.23
England	7	2.82
Iran	6	2.42
Sweden	5	2.02
Ireland	4	1.61
Hungary	4	1.61

Figure 3 shows the international co-authorship relations of African countries with non-African countries. Of total 28 non-African countries, the researcher from African countries collaborated with authors located in 12 European countries. Researchers from Namibia and Cameroon are not collaborated with other than African counterparts. Researchers from Uganda collaborated only with Ireland.

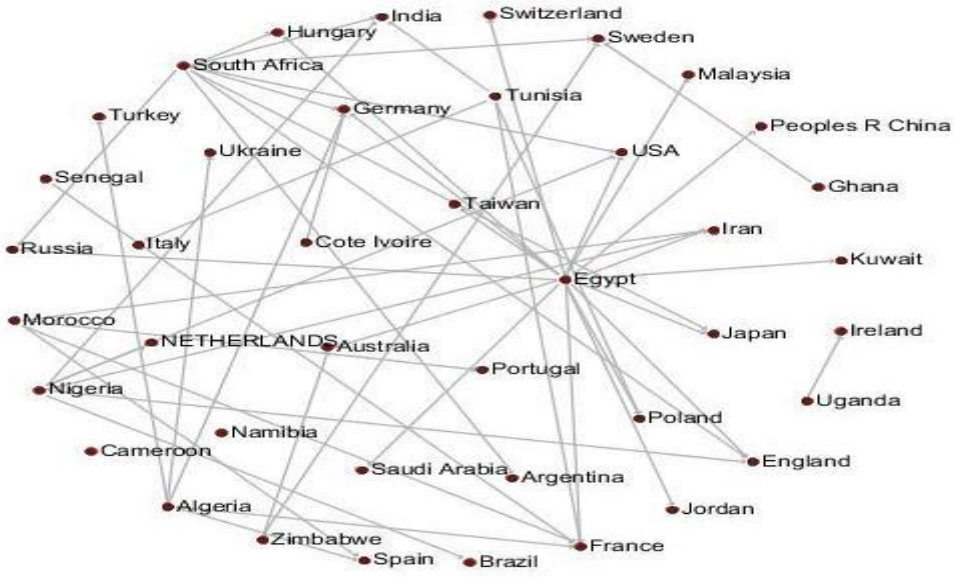

Figure 3 – Country level collaborations with non-African countries

Table 4 provides the list of most prolific institutions in tribology research on the African continent.Non-African institutions are excluded from this list. Egyptian (5), South African (3) and Tunisian (2) institutionsdominate the tribology research. These three top countries are the top most productive three countries among the African countries (see Table 2).

Table 4 – Top 10 most productive African institutions		
Institution	Country	# Articles

EcoleNatlIngnSfax	Tunisia	19
AssiutUniv	Egypt	14
Mansoura Univ	Egypt	12
Tshwane UnivTechnol	South Africa	11
Univ Cape Town	South Africa	9
UnivSfax	Tunisia	9
Univ Witwatersrand	South Africa	8
Cairo Univ	Egypt	6
MeniaUniv	Egypt	6
ZagazigUniv	Egypt	6

Total 248 articles in tribology were published by 572 authors. Table 5shows the list oftop 10 most prolific authorsin tribology research on the African continent. Non-African authors are excluded from this list. The top ten most productive authors are also from the top three countries such as Tunisia, Egypt and South Africa.

Table 5 – Top 10 most productive African authors

Author	Affiliation	# Articles
Elleuch R	EcoleNatlIngenieursSfax, Tunisia	15
Elleuch K	EcoleNatlIngenieursSfax, Tunisia	12
Sarhan AAD	AssiutUniv, Egypt	10
Dammak M	UnivSfax, Tunisia	9
Kharrat M	EcoleNatlIngenieursSfax, Tunisia	9
Kchaou M	EcoleNatlIngenieursSfax, Tunisia	7
Mostafa MM	Mansoura Univ, Egypt	6
Youssef AA	Atomic Energy Authority, Egypt	6
Ayedi HF	EcoleNatlIngenieursSfax, Tunisia	5
Marcus K	Univ Cape Town, South Africa	5

The 248 articles by African scientists in tribology research were published in 103 journals. Table 6shows the names of the journals with the numbers and percentages of articles published by each journal. Only journals that had published at least 5 of these articles are

listed in Table 5. Almost 42% of total output was published in top nine journals and these journals having impact factor (2014) more than 1.

Table 6 – Most preferred journals

Journal	# Articles	%	IF 2014
WEAR	30	12.10	1.913
SURFACE & COATINGS TECHNOLOGY	16	6.45	1.998
MATERIALS & DESIGN	15	6.05	3.501
TRIBOLOGY INTERNATIONAL	9	3.63	1.936
JOURNAL OF MATERIALS PROCESSING TECHNOLOGY	9	3.63	2.236
TRIBOLOGY LETTERS	7	2.82	1.739
INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY	7	2.82	1.458
VACUUM	6	2.42	1.858
JOURNAL OF TRIBOLOGY-TRANSACTIONS OF THE ASME	5	2.02	1.101

Top 10 highly cited articles authored by African scientistsare listed in table7. These articles received citations in the range between 28 and 110. Six out of 10 articles were published after 2000 and remaining between 1991 and 1999. Five articles of highly cited articles were published with international collaboration with countries outside African continent. The journal *Wear* holds the most of highly cited articles with 4 publications as this journal is top most preferred journal (see Table 5). Some journals (e.g. *Polymer*, *Textile*, and *Dental Materials*) had only one publication by African scientists and that article also highly cited one.

Table 7 – Highly cited articles by African scientists

Article	TC	Type
Epoxy/graphene platelets nanocomposites with two levels of interface strength. *Polymer*, 52(7): 1603-1611 (2011)	110	ICP
Friction and wear properties of polymeric composite-materials for bearing applications, *Wear*, 184 (1): 45-53 (1995)	46	SCP
Warm-cool feeling relative to tribological properties of fabrics. *Textile Research Journal*, 71 (9): 806-812 (2001)	46	ICP
The tribologicalbehaviour of glass filled polytetrafluoroethylene. *Tribology International*, 38 (9):	34	SCP

824-833 (2005)		
The sliding wear of ultrahigh molecular-weight polyethylene in an aqueous environment. *Wear*, 178 (1-2): 17-28 (1994)	34	SCP
Influence of surface conditioning and cleaning methods on resin bonding to zirconia ceramic. *Dental Materials*, 27 (3): 207-213 (2011)	34	ICP
Tribological behavior of unfilled and composite polyoxymethylene. *Wear*, 148 (2): 363-376 (1991)	32	SCP
Identification of a friction model at tool/chip/workpiece interfaces in dry machining of AISI4142 treated steels. *Journal of Materials Processing Technology*, 209 (8): 3978-3990 (2009)	31	ICP
Austempered ductile iron: an alternative material for earth moving components. *Cement & Concrete Composites*, 25 (6): 643-649 (2003)	29	SCP
Influence of electric fields on the tribologicalbehaviour of electrodynamical copper/steel contacts. *Wear*, 203: 434-441 (1997)	28	ICP
SCP – Single country publication, ICP – International collaborative publication		

CONCLUSION

The bibliometric analysis of tribology research output contributed by African authors reveals some interesting findings. More than 90% of the total output was contributed by top five African countries: Egypt, Tunisia, South Africa, Algeria and Nigeria. Inequalities in research published on tribology research exist among African countries.Authors from Egypt, Tunisia and South Africa are engaged in tribology research more than other African countries. Empirical data reveals that the contributions by African countries to world science in tribology research are very low. The results of this study suggest that the research activities in the field of tribology from Africashould be encouraged and African institutions need to improve on bothimpact and quality of research output on par with global trend in the field.Future bibliometric analyses of articles published by African researchers will be focused to examine the collaboration at author and institutional level which will be of interest among the research community and useful to choosing the partner for collaboration.

REFERENCES

Adams J, et al. (2014). International collaboration clusters in Africa. *Scientometrics*, 98 (1), 547-556.

Adams J, King C & Hook D (2010).Global ResearchReport of Africa, Thomson Reuters.ISBN 1-904431-25-9.

Boshoff N (2009). Neo-colonialism and research collaboration in Central Africa.*Scientometrics*, 81(2), 413-434.

Breugelmans J G, et al (2014). Bibliometric assessment of European and Sub-Saharan African research output on poverty-related and neglected infectious diseases from 2003-2011.*Plos Neglected Tropical Diseases*, 9(8), e03997.

Chuang K Y, et al. (2011). Bibliometric analysis of public health research in Africa: the overall trend and regional comparisons. *South African Journal of Science*, 107(5/6), Art.#309.

Dragos C M and Dragos S L (2014). Scientific productivity versus efficiency of R & D funding: bibliometric analysis of African countries. *Current Science*, 106(7), 942-945.

Elango B, Rajendran P and Bornmann L (2013). Global nanotribology research output (1996-2010): a scientometric analysis. *Plos One*, 8 (12), e81094.

Elango B, Rajendran P and Bornmann L (2015).A scientometric analysis of international collaboration and growth of literature at the macro level.*Malaysian Journal of Library and Information Science*, 20 (2), 41-50.

Goehl TJ, Flanagin A (2008). Enhancing the quality and visibility ofAfrican medical and health journals.*Environ Health Perspect*, 116, A514–5.

Hofman K J, et al (2009). Mapping the health research landscape in sub-saharan Africa: a study of trends in biomedical publications.*Journal of the Medical Library Association*, 97(1), 41-44.

Irikefe V, et al. (2011). Africa's nations are achieving some success in building their science capacity, but the foundations remain unsteady.*Nature*, 474, 556-559.

Khan M (2011).A bibliometric analysis of South Africa's scientific outputs – some trends and implications.*South African Journal of Science*, 107(1/2), Art.#406.

Megnigbeto E (2013). Scientific research in west Africa: a global view (2001-2010). *ISSI Newsletter*, 9(1), 6-11.

Mêgnigbêto E (2013). Scientific publishing in West Africa: a comparison of Benin with Senegal and Ghana.*Scientometrics*, 95 (3), 1113-1139.

Mouton J (2010).The state of social science in sub-Saharan Africa.World Social Science Report. pp. 63-67.

Ocholla D, et al. (2012). Research visibility, publication patterns and output of academic librarians in Sub-Saharan Arfica: the case of Eastern Africa. *Aslib Proceedings*, 64(5), 478-493.

Schemn Y (2013). Africa doubles research output over past decades, moves towards a knowledge-based economy. *Research Trends*, 35, 11-12.

Sooryamoorthy R (2013). Scientific collaboration in South Africa.*South African Journal of Science*, 109(5/6), Art.#a0016.

Swan P G and Fitton J C. The South African Institute of Tribology SA Tribology Project 2010.

Tijssen R (2015). Research output and international research cooperation in African flagship universities.In:Cloete N, MaassenP and Bailey T (eds.).*Knowledge Production and Contradictory Functions in African Higher Education*, pp.61-74.
